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THE QUARTERLY REVIEW of BIOLOGY

# THE CHEMISTRY AND PHYSIOLOGY OF LIGNIN FORMATION

BY S. M. SIEGEL

*Department of Biology, University of Rochester*

## INTRODUCTION

THE biology and chemistry of lignins are of great importance, both as fundamental and applied areas of knowledge. Botanically, the abundance of lignins in higher plants and their strategic location in conducting and supporting tissues have led to the belief that these compounds are of great importance in the evolution of the upright land plant, particularly the arboreal form. Biochemically, this group of substances provides information about transformations of aromatic nuclei unique to the plant cell. Lignins, as the most refractory of organic materials in the plant, constitute the principal starting material for humus formation, and hence are a major part of the organic ground substance of soils. Lignins determine, to a great extent, the properties of woods; therefore, profitable wood and paper technology requires an understanding of their nature and formation. As their sulfonated derivatives, lignins constitute the main by-product of the paper pulp industry, and one for which little use has been found to the present.

Broadly, the lignins are a class of inert aromatic substances commonly associated with the xylem in the Tracheophyta, and of infrequent occurrence in non-vascular plants. Within the higher plant, lignins are a major cell-wall component of the wood fiber. The most lignified portion of the cell is the middle lamella, which may be more than 70 per cent lignin (Bailey, 1936); however, the walls of virtually any cell, save those of the general meristem, may be lignified to a greater or lesser degree, including those of roots and root hairs (Krömer, 1903).

In addition to their presence in vascular and mechanical tissues, lignins can be readily demonstrated in seeds, seed coats, epidermal cells, and, in *Humulus* and *Liriodendron*, in woody perianth (Angell and Norris, 1936). The composition of the wood cell undergoes a transition from essentially pure carbohydrate around the lumen of the cell to almost pure lignin in the middle lamella (Jayme and Wettstein, 1938). The secondary walls of fibers from deciduous woods are almost unlignified, whereas the primary wall is a region of high lignin content (Harlow, 1928).

Lignified cell walls, and isolated lignins as well, yield characterizing color reactions with a variety of reagents. In the most common color test, tissues are treated with phloroglucinol in strong hydrochloric acid (Norman, 1937); a deep magenta color develops rapidly if even microgram quantities of lignin are present. A more specific test, yielding scarlet to magenta colors within a few minutes (Siegel, 1954), involves mild chlorination of tissues followed by application of aqueous sodium sulfite. For the Mäule test, tissues are chlorinated, but sulfite is replaced by dilute ammonia; this procedure reputedly differentiates between the lignins of deciduous and coniferous woods (Norman, 1937). Lignified tissues become green in 44

per cent hydrochloric acid and black in 72 per cent sulfuric acid, the colors being discharged on dilution with water.

The specificity of the phloroglucinol test has been the subject of some uncertainty (Brauns, 1952), but when the test is refined by preextracting the tissues with a series of solvents, from water to benzene or other hydrocarbons (Brauns, 1952; Norman, 1937), the color produced in tissue can be attributed to lignins to the exclusion of other aromatic substances.

Although such terms as lignocellulose are common, current evidence suggests only that lignins may exist in chemical combination with other high molecular cell wall constituents. Freudenberg, Harder, and Markert (1928) and Freudenberg (1933) have attempted to account for the differential solubility and other properties of isolated and in situ lignins on the basis of purely physical cell-wall models in which the complex intermingling of the several wall components creates mechanical barriers to movement of materials. Recent work, however, indicates that the views of Freudenberg and his coworkers cannot be entirely correct. Kawamura and Higuchi (1953a, b, 1954) established the chemical association of the pentose, xylose, with the residual lignin in essentially delignified beechwood pulps. In beechwood, part of the combination may exist as a 1,4′ linkage of two xylose molecules at the lignin $C_1$. Traynard and Ayroud (1954) demonstrated that in poplar wood, not only xylose, but arabinose or galactose as well, may be linked with lignin to form a chemical combination requiring vigorous hydrolysis for its separation.

## THE PROPERTIES OF LIGNINS

Treatises dealing specifically with lignin are generally too detailed and time-consuming for the non-specialist. Hence, to provide an adequate orientation, a brief account of the physical and chemical characteristics of lignins follows.

*Physical Properties.* Freudenberg et al. (1936) distinguished between unformed and formed lignins. The former are soluble in neutral organic solvents and occur in the traces of sprucewood, whereas the latter, insoluble in neutral solvents, constitute the bulk of wood. Lignins, as generally considered, are resistant to boiling water at atmospheric pressure, to both dilute and strong non-oxidizing acids, and to neutral organic solvents, but are soluble in sulfites, bisulfites, alkalis, or organic acids as catalysts. Few agencies in nature, save for limited groups of microorganisms, can accomplish more than a superficial alteration of the lignin molecule. Most lignins dissolve only in reaction solvents (Jodl, 1942), as in ethanolysis (on treatment with ethanol-HCl), phenolysis, or sulfonation. The solubility of lignins often changes with isolation. Mild procedures increase subsequent solubility and vigorous ones reduce it. Save for their solutions in phenol and dioxan, lignins generally form colloidal dispersions in organic solvents.

The exact shapes and sizes of lignin molecules are not yet established. Lignins which have been isolated in soluble form, and hence were subjected to degradative conditions, have low specific viscosities. They are likely to consist of perhaps 5 to 6 phenylpropane (monomer) units more spherical than threadlike in form. Shape factors obtained from sedimentation and diffusion experiments, and by determination of dielectric constant ratios (Brauns, 1952) range from 5 to 8 for molecular weights of 4000 to 7000. The disposition of lignin in wood suggests a large, tridimensional (that is, multidirectional) molecule of completely irregular shape (Freudenberg and Braun, 1928).

Techniques involving controllable and measurable modification of the lignin molecule have been applied in the hope of obtaining a figure for the lowest molecular weight. Included among these methods are benzoylation, methylation, and bromination; values obtained approximate 190, or a multiple thereof. The most frequently obtained number is 800 to 900, and, consistent with the viscosimetric data, would approximate 5 to 6 phenylpropane residues. Assuming an essentially spherical shape for the lignin molecule, diffusion methods give a molecular weight of 860 to 11,000, depending upon the means of isolation. Osmometric determinations provide far more consistent values, 3800 to 4500. In all likelihood, therefore, the value of 800 to 900 must itself be regarded as the weight of a unit, of which the lignin molecule is a multiple.

Consistent with their aromatic nature, lignins possess a high index of refraction and shown strong ultraviolet absorption in the region, 260 to 290 mμ. Lignins isolated by removal of carbohydrates retain essentially the structure of the original wood, with open spaces representing the former location of carbohydrates. Examination of such material with plane-polarized light shows a birefringence, actually form double refraction, a

TABLE 1

*Degradation products of lignin*

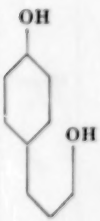
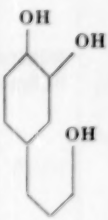
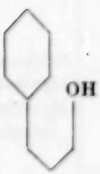
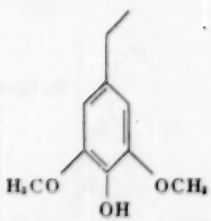
| COMPOUND | STRUCTURE | SOURCE | TREATMENT |
|---|---|---|---|
| Formaldehyde | HCHO | Many woods | $H_2SO_4$ |
| Cyclohexanol | | Wood | $H_2$, Ni |
| 4-*n*-Propylcyclohexan-1-ol | | Willstätter and hydrol lignin | $H_2$, Ni |
| 3-(4-Hydroxycyclohexyl)-propanol |  | Willstätter and hydrol lignin | $H_2$, Ni |
| 3-(3,4-Dihydroxycyclohexyl)-propanol |  | Willstätter and hydrol lignin | $H_2$, Ni |
| 3-Cyclohexylpropanol |  | Hydrol lignin | $H_2$, Ni |
| 1-Ethyl-3,5-dimethoxy-4-hydroxybenzene |  | Hydrol lignin | $H_2$, Ni, acid |

TABLE 1—*Continued*

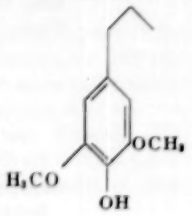
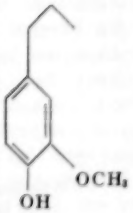
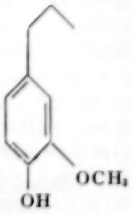
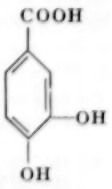
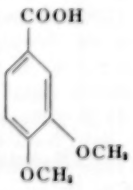
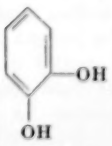
| COMPOUND | STRUCTURE | SOURCE | TREATMENT |
|---|---|---|---|
| 1-(2-Ethanol)-3,5-dimethoxy-4-hydroxybenzene |  | Hydrol lignin | $H_2$, Ni, acid |
| 1-*n*-Propyl-3-methoxy-4-hydroxy-benzene (dihydroeugenol) |  | Willstätter lignin<br>Hydrol lignin<br>Ethanol lignin | $H_2$, Ni<br>$H_2$<br>Na, liq. $NH_3$ |
| 1-Ethyl-3-methoxy-4-hydroxy-benzene |  | Hydrol lignin | $H_2$, acid, Ni |
| 3,4-Dihydroxybenzoic acid (protocatechuic acid) |  | Willstätter lignin<br>Ba ligno-sulfonate | $H_2$, Ni<br>$Ba(OH)_2$ |
| 3,4-Dimethoxybenzoic acid (veratric acid) |  | Softwoods<br>Lignosulfonic acids<br>Methylated spruce woods | $KMnO_4$<br>$KMnO_4$<br>$KMnO_4$ |
| 1,2-Dihydroxybenzene (catechol) |  | Ba ligno-sulfonate | $Ba(OH)_2$ and Zn, $H_2$ |

TABLE 1—*Continued*

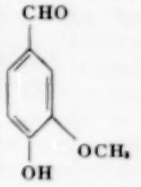
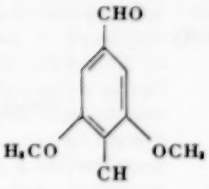
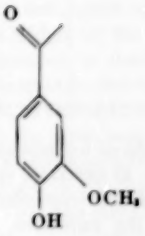
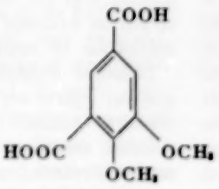
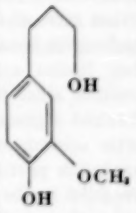
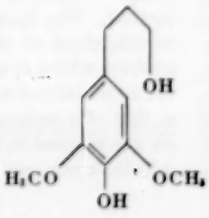
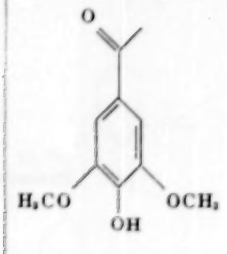
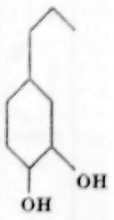
| COMPOUND | STRUCTURE | SOURCE | TREATMENT |
|---|---|---|---|
| 3-Methoxy-4-hydroxybenzaldehyde (vanillin) |  | Sulfite waste liquor | $Ca(OH)_2$<br>KOH<br>$Ag_2O$<br>$C_8H_5NO_2$ |
| 3,5-Dimethoxy-4-hydroxybenzaldehyde (syringaldehyde) |  | Hardwoods | KOH |
| 3-Methoxy-4-hydroxyacetophenone (acetovanillone) |  | Softwoods | KOH |
| 3,4-Dimethoxy-1,5-dicarboxybenzene (isohempinic acid) |  | Softwoods<br>Alcohol lignin<br>Spruce | $KMnO_4$<br>$KMnO_4$<br>$KMnO_4$ |
| 3-(3-Methoxy-4-hydroxyphenyl)-propanol |  | Hydrol lignin | $H_2$, Ni |
| 3-(3,5-Dimethoxy-4-hydroxyphenyl)-propanol |  | Hydrol lignin | $H_2$, Ni |

TABLE 1—*Concluded*

| COMPOUND | STRUCTURE | SOURCE | TREATMENT |
|---|---|---|---|
| 3,5-Dimethoxy-4-hydroxy-acetophenone (aceto-syringone) |  | Willstätter lignin<br>Lignosulfonic acid | $H_2$, Ni<br>KOH |
| 1,2-Dihydroxy-4-*n*-propylcyclohexane |  | Willstätter lignin | $H_2$, Ni |

property of lignin net-works which follow the original orientation of the cellulose micellae among which the lignin molecules were deposited.

The preponderance of x-ray data suggests that lignins are amorphous substances. Further, woods yield essentially the powder diagrams of the isolated cellulose itself. X-ray diffraction methods and other modes of physical analysis seem to agree with the concept that the lignins are built from irregularly placed units forming a shapeless mass. Harris, et al. (1932), Jodl (1942), and a few other workers have reported definite crystal structures for lignins. Conceivably, some lignins may show an oriented structure; for example, crystalline polymers of low molecular weight may form associations of a higher order, but with varying degrees of randomness, as dictated by the particular physical and chemical condition of the cell wall.

Polarimetry, like x-ray analysis, has yielded no unequivocal or conclusive data. From a general knowledge of lignin structure, as well as the general synthetic activities of the cell, lignins might be expected to possess optical activity. The deep colors of true solutions of lignins, and their tendency otherwise to form colloidal dispersions place technical difficulties in the way of successful polarimetric work. Freudenberg and Öhler (1931) proposed that the inactivity of lignins might be a consequence of aging, even in the tree, but, in any case, optical inactivity does not preclude the occurrence of asymmetric carbon atoms in the molecules. Adler and Lindgren (1952) suggest that the lack of optical activity be construed as evidence for the non-enzymatic polymerization of radicals during lignin formation.

*Chemical Properties.* The techniques for degrading lignins are numerous. The diversity of products obtained is formidable (Table 1). For a detailed treatment of degradation studies, the reader is referred to the books of Brauns (1952) and Wise (1944). Bonner (1950) has organized the important facts of lignin constitution in readily comprehensible form.

When lignins are subjected to thermal decomposition, alkali fusion, nitrobenzene oxidation, and kindred degradative procedures, a variety of aromatic substances is released possessing the hydroxylation patterns of monophenol, catechol, or pyrogallol in the form either of free hydroxyl groups or their methyl ethers (as in guaiacol or veratrol). The hydroxylated nuclei may possess no side chain or may be derivatives of phenylmethane, ethane or propane. The side chain may be at any oxidation level from that of a hydrocarbon to that of a carboxylic acid. Aliphatic fragments are also released on degradation, including formaldehyde, acetic and oxalic acids, and acetone.

A substance of particular interest formed during alkali fusion of lignins is isohemipinic acid (3,4-dimethoxy-1,5-dicarboxybenzene) which figures importantly in current views on lignin structure.

The detailed structure of the lignin molecule is as yet uncertain. There is good reason to believe that lignin molecules are as diversified as the number of species of plants which synthesize them, and perhaps more so, when the variations in lignin composition with age are considered. Hence, we now seek a generalized structure for at least a part of such a molecule. The results of degradation studies indicate lignins to be constituted as follows: (a) the largest unit obtained, a phenylpropane ($C_6$-$C_3$), forms the basic structural unit of the molecule; (b) the aromatic nucleus contains an oxygenated functional group, a hydroxyl group or its methyl ether; (c) the release of phenolic hydroxyl groups from lignins on sulfonation suggests the presence of an oxygen bridge; (d) the $C_3$ side chain contains oxygen functions or double bonds, or both, rendering possible $\alpha\beta$ or $\beta\gamma$ cleavage into $C_6$-$C_1$ and $C_6$-$C_2$ compounds, as well as $C_1$ and $C_2$ aliphatic fragments; and (e) the occurrence of isohemipinic acid implies that a carbon-to-carbon bond exists between the side chain of one $C_6$-$C_3$ unit and the ring of the next. That this degradation product occurs in relatively low percentage may be explained on the basis of its further decarboxylation to veratric acid and veratrole.

Dehydrodiisoeugenol, containing a hydrofuran ring (Freudenberg, 1939) and Russell's polyflavanone (1947) show the manner in which phenylpropanes may be linked in lignins (Fig. 1). Present evidence permits either of these structures to be applied to various lignins, or indeed to exist in the same species of plant. DeStevens and Nord (1953) proposed a flavone structure for bagasse lignin on the basis of spectral studies and the behavior of the material on methylation.

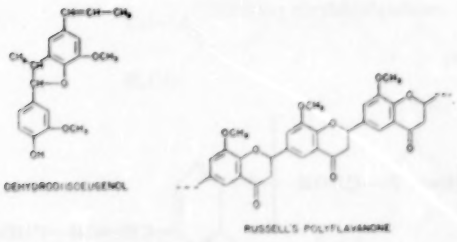
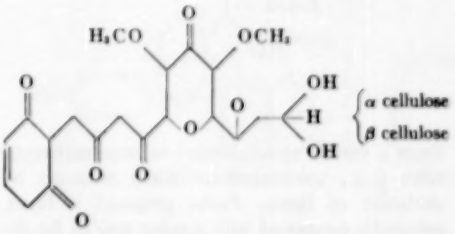



FIG. 1. POSSIBLE STRUCTURAL UNITS IN THE LIGNIN MOLECULE

The integration of analytical data into proposed structures for the lignin molecule has been attempted by numerous investigators and the results of such efforts are not without their interest, although some of these proposals are today chemically groundless.

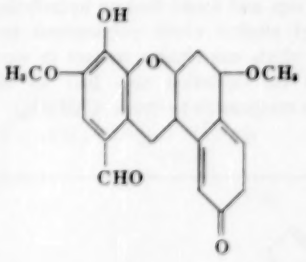
The first three structures listed below are meant to be the complete lignin molecule but the remainder have been presented as lignin building stones.

*Cross and Bevan's Formula (1893)*



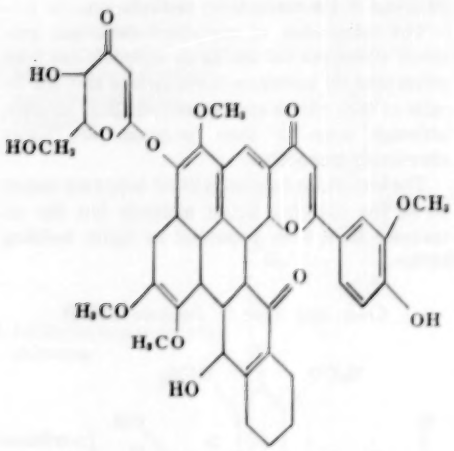

This formula, the first proposed for lignin (then called "lignone"), was based principally on the similarity of the chlorination products of lignin and pyrogallol and the fact that acetone and acetic acid were obtained by destructive distillation. No evidence was presented for the oxirane ring.

*Doree and Barton-Wright's Formula (1927)*



Based on an investigation of "metalignin", this formula was suggested. The structure may be visualized as a combination of a phenylethane and phenylpropane unit and some evidence was presented supporting a six-membered pyran ring. The structure does not explain the formation of vanillin on oxidation with nitrobenzene.

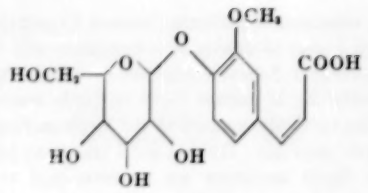
*Fuch's Formula (1936)*



From a variety of substituted benzene carboxylic acids (e.g., protocatechuic acids) obtained by oxidation or lignin, Fuchs proposed a fused, polycyclic compound with a sugar residue for the lignin molecule. Besides failing to account for vanillin on oxidation and cyclohexylpropane derivatives on hydrogenation, the carbon and methoxyl contents are higher than that observed for Klason and Willstätter lignins.

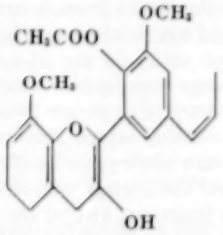
*Klason's Theory (1897)*

Klason investigated coniferin, a glucoside of conifer sap, and found that on hydrolysis, it gave coniferyl alcohol which polymerized to a substance which was similar to tars in wood, gave vanillin on oxidation and had an elemental analysis comparable to lignin ($C_{40}H_{42}O_{12}$).

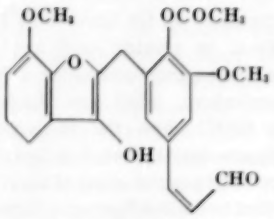


**Coniferin**

From these results Klason first suggested that lignin might be formed by condensation of two coniferylaldehyde molecules. He preferred the furan over the pyran ring.

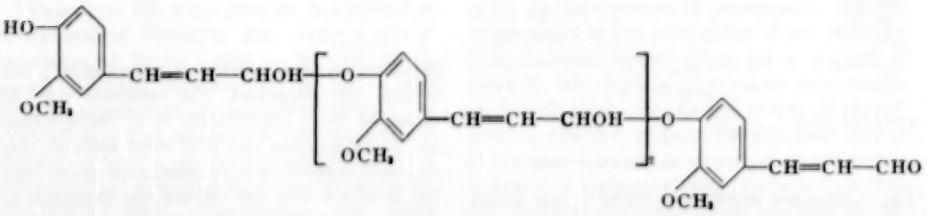


pyran form



**furan form**

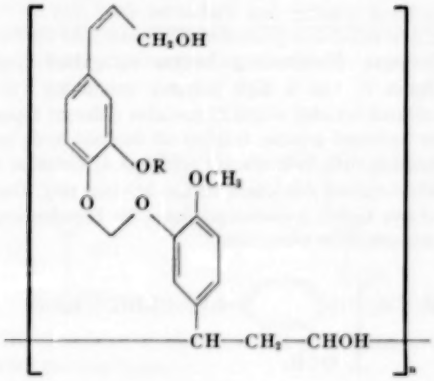
He later revised the formula to a straight-chain coniferylaldehyde polymer.



However such acetal linkages would be readily hydrolyzed in dilute acids giving only coniferylaldehyde.

*Kürschner's Lignin Formula (1935)*

Like Klason, Kürschner believed that coniferyl alcohol was the building stone of lignin and proposed the following formula.



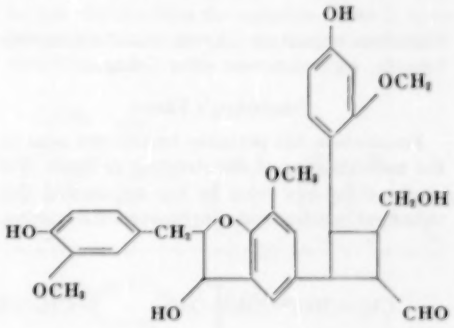

Besides lacking phenolic hydroxy and carbonyl groups, the structure contains methylenedioxy linkages and double bonds; neither have been confirmed for lignin.

*Pavolini's Formula (1931)*

Pavolini considered hydroxy coniferyladehyde as the building stone but his formula also contained acetal linkages which do not conform with experimental evidence.

*Rassow and Gabriel's Formula (1931)*

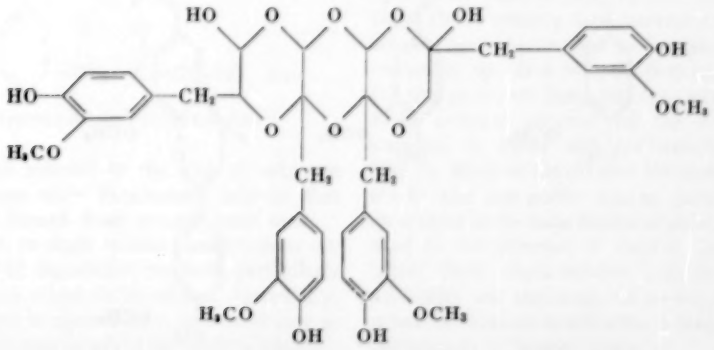
Another formula, proposed by Rassow and Gabriel and based on Klason's hypothesis that coniferyl derivative was the main building stone, may be visualized as being formed by condensation of two coniferyl alcohol residues and one coniferyl alcohol residue.

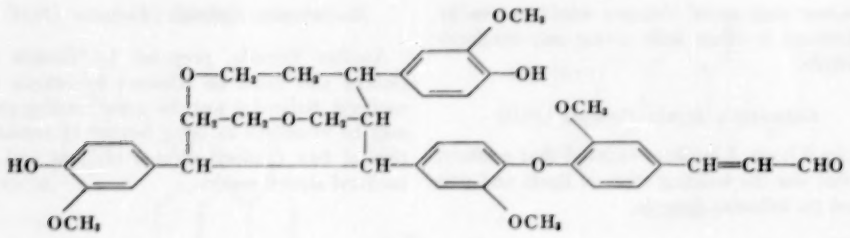



This structure, however, contains more hydroxy groups than is compatible with experimentally determined values.

*Chambovet's Formula (1921)*

Condensation of four molecules of coniferyl aldehyde with the elimination of three molecules of water was considered by Chambovet as the mode of lignin formation.

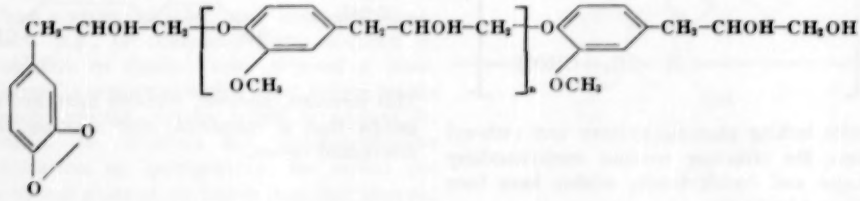




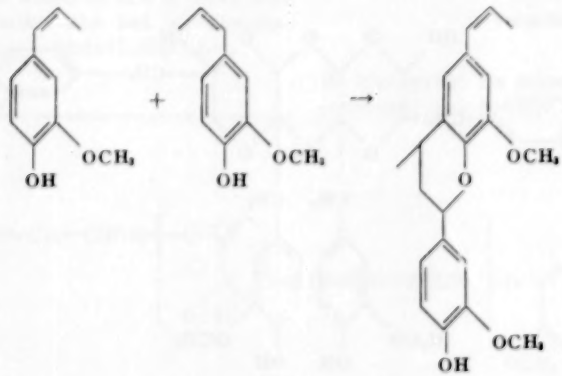
Numerous objections may be raised aginst this formula, e.g., numerous ether linkages.

### *Freudenberg's Theory*

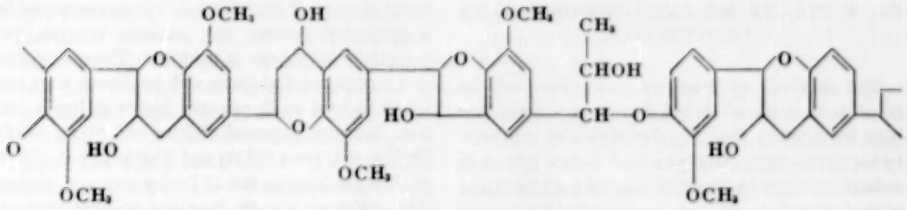
Freudenberg has probably contributed most to the understanding of the structure of lignin. For nearly thirty-five years he has approached this structural problem with emphasis on the building stones or basic units of lignin. Quite early he proposed the following empirical formulae for the basic unit of lignin: $C_9H_{10}O_3$, $C_{10}H_{10}O_3$ and $C_{10}H_{12}O_3$. He considered the three oxygen atoms to be present as methoxyl, hydroxyl and ether linkages. Freudenberg further recognized that lignin 1) was a high polymer containing substituted benzene rings, 2) contains different types of hydroxyl groups, 3) splits off formaldehyde on heating with hydrochloric acid and 4) contains a three-carbon side chain on the benzene ring. One of the earlier formulas proposed by Freudenberg accounted for these facts.



Even when this formula was presented Freudenberg was considering the idea of nuclear (ring) condensation. Later Erdtman and Freudenberg observed that mild oxidation of isoeugenol gave dehydrodiisoeugenol, a nuclear condensation product, which has some of the properties of lignin.



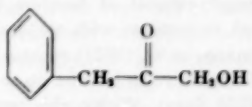
Isolation of isohemipinic acid on oxidation of lignin (and dehydro-isoeugenol) proved nuclear condensation involving the five position, i.e., adjacent to the phenolic hydroxyl group. In 1939 Freudenberg presented the formula below which accounts for these facts. The structure consists of guaiacylpropane derivatives bifunctionally combined by nuclear condensation into a high polymer. The ether linkages are present in furan and pyran rings and both secondary and tertiary hydroxy groups are present. (Freudenberg now believes that a primary hydroxy group must be present.)




The elementary composition is in good agreement with cuoxam lignin.

### *Hibbert's Theory*

At first Hibbert considered lignin to be a condensation product of fructuronic acid and guaiacyl residues, but soon abandoned this idea in favor of a formula somewhat like that of Freudenberg. However, Hibbert considered the three-carbon side chain to be a 1-hydroxy-2-keto-3-phenylpropane group, thus involving primary hydroxyl groups (Freudenberg preferred secondary and tertiary hydroxyl groups) and no terminal methyl groups.




1-hydroxy-2-keto-3-phenylpropane

Hibbert also adhered to the idea of only one building stone while Freudenberg believed that lignin was formed from several basic units.

Obviously, no single specific phenlypropane can account for all degradation products, particularly for substances of high $OCH_3$ content. Accordingly, the structures in figure 1 need be treated only as models and it may be left to the reader's ingenuity to choose from among the wealth of aromatic substances in the plant cell, a suitable diverse compliment of monomeric units for building the lignin molecule. We do not know whether several somewhat different phenylpropanes are united in the low polymer comprising the building unit, or alternatively, if low polymers of like phenylpropanes join with slightly different units to build the high polymer; without more information on periodicity within the molecule, there is more license than basis for the drawing of a detailed structure.

## THE MECHANICAL CONSEQUENCES OF LIGNIN DEPOSITION

Paech (1950) described the lignins as the principal skeletal substances of the higher plant, and Bailey (1953) related lignin in tracheary tissue to support of the plant body. Approaching the problem of support phylogenetically, Bailey further concluded that little or no cambial activity could be associated with low forms, and high sustained activity with the arboreal form. Ciesler (1897) found many years ago that the lignin content of sprucewood, measured over the length of the tree, was highest in regions of greatest mechanical strain. Although Ciesler's methods of lignin determination are subject to criticism, Siegel (1955) recently demonstrated a correlation between lignin content and the increasing pressure exerted by the plant on itself, from apex to base. For this study, the Poinsettia stem was used, and direct evidence obtained for the simultaneous variation in lignin and mechanical gradients (Fig. 2). Many of the obvious differences between woody and non-woody tissues, particularly as these occur in the same species of plant, can be related to the presence of varying quantities of lignin. Such characteristics include hardness, wettability and shrinkage. Of course, anatomical as well as chemical modification is involved in the development of lignified tissues.

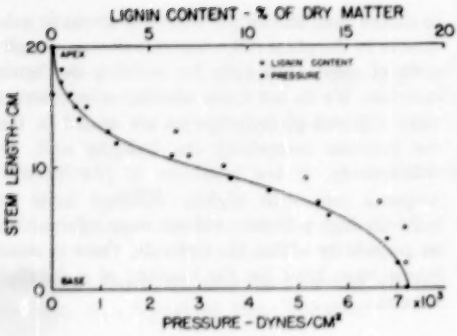



FIG. 2. PRESSURE AND LIGNIN GRADIENTS IN THE POINSETTIA STEM

The synthesis of lignin by tissue slices will be considered in detail later, but it is appropriate here to mention that the deposition of synthetic lignin (from eugenol) in pea root tissues results in radical changes in some of the properties noted above. Segments of root containing 43 per cent synthetic lignin lost only 50 per cent of their volume on drying, whereas control tissues (endogenous lignin 0.2 per cent) exhibited a 95 to 99 per cent shrinkage when dried to constant weight (Siegel, 1954). Synthetically lignified tissues were less wettable in water and dilute acids, and did not tend to swell as much as did control tissues when placed in dilute alkali.

We can, therefore, invoke a certain amount of evidence supporting mechanical modification of tissues on their impregnation with lignin. The lignin, in forming a "packing material" within the structure of the cell wall, alters the compressibility far more than the tensile strength of woods particularly in view of Freudenberg's demonstration that chemical combination between lignin and cellulose is not required to account for the behavior of wood and its components.

## CHANGES IN LIGNIN CONTENT DURING GROWTH AND DEVELOPMENT

If we are correct in our conception of lignins as functionally significant entities, it is desirable that we relate changes in lignin content to other events occurring in the life of the plant and its parts. Unfortunately, plant physiologists have not actively included lignins within their domain, although lignins constitute a large proportion of the dry matter, and a still greater fraction of the aromatic substance of the higher plant. In lignin chemistry itself, most attention has been given to the mature cell wall.

Allsopp and Misra (1940) determined percentages of lignin and other cell wall components in cambium, new wood and sap wood of several tree species. They found that during differentiation, twofold increases in cellulose content were accompanied by two- to fourfold increases in lignin content, and drastic reductions in pectin, uronic anhydride and protein content. Even after vessel differentiation, small changes in composition appeared. Harlow and Wise (1928) found rays to be consistently higher than wood in lignin content. The difference was accompanied by a somewhat lowered ray cellulose content, but essentially no change in pentosan. The springwood of a number of deciduous and coniferous trees was found to be 4 to 25 per cent higher in lignin content than summerwood (Ritter and Fleck, 1922). Phillips and Goss (1935) and Phillips, et al. (1939) studied the lignification of barley and oats, finding that, although the absolute and relative amounts of lignin increased in the plants during development, the absolute quantities of cellulose and pentosans did not decrease, but also became higher. The methoxyl content increased from 2 per cent in the lignin of younger plants to 11 per cent in the lignin of the mature form. Buston (1935) found that both lignin and pectic substances increased in absolute content during development of the rose plant. Higuchi, et al. (1953) studied lignification in bamboo (*Phyllostachys* spp.), observing that the initial lignification of the spiral vessel at the shoot apex was extended with age to include the entire vascular bundle. Parenchymatous tissue remained unlignified until plants attained a height of 5 meters or more. The methoxyl content of bamboo lignins was again found to increase with maturation of the cell. Beckmann, et al. (1923) reported the lignin content of winter rye to increase up to a height of 130 cm. (223 days). Within this period, plants growing from 22 to 130 cm. increased in lignin content 13 to 17 per cent but the methoxyl content of the lignin rose from an initial value of 3 per cent to a final content of 11.5 per cent. Bower et al. (1943) found no lignin in 3 week old spruce buds, but about 20 per cent lignin (determined as 4-propyl-cyclohexanol after hydrogenolysis) in 3.5 to 4.0 month old material. Griffoen (1938) studied changes in the cell walls of sunflower and found increases in lignin and pentosan fractions to

be associated with reduction in uronic acids during the growth of the plant.

These scanty data permit no sound generalizations. However, they suggest that no particular cell wall component varies consistently, from species to species, as lignin content increases, and that the first-formed lignins are chemically distinct from those commonly studied in older tissues.

The place of environmental factors in lignin formation has been neglected. It is common knowledge that greenhouse-grown plants are often mechanically underdeveloped, particularly when light intensity is low and the temperature high. The author has noted that etiolated Red Kidney beans after about 2 weeks of growth contain less than half the lignin of light-grown plants, and, further, that beans grown under 8 hours of high intensity, natural illumination produce much less lignin than comparable plants given a supplemental 8 hours of low intensity artificial light.

Taylor, working in the Earhart Plant Research Laboratory of the California Institute of Technology, grew tomato plants under artificially windy and still conditions, observing that the mechanical tissue increased under the stress of wind. Although this difference has not as yet been subjected to chemical or histochemical analysis, it is likely that a higher lignin content accounts in part for the increased supporting tissue of the wind-grown plant.

Water plants such as *Elodea* and the fern, *Ceratopteris* (examined by the author) possess only traces of lignin, and it may be proposed that the return of a vascular plant to an aquatic habitat is associated with a prior loss of lignin-forming capacity. The support of such plants depends either on the buoyancy of their medium or on the development of a turgid aerenchymatous tissue. In anticipation of information presented below, it may be pointed out here that such a mechanically deficient plant as *Elodea* retains a potential for lignin formation which is realized only when the proper materials are provided.

## FORMATION OF LIGNINS FROM HYDROXYPHENYLPROPANES

### *General Theories of Lignin Formation*

Even in recent years there have been investigators who have chosen to regard lignins as artifacts, produced as a consequence of the treatments intended to isolate them. Although it is true that sulfuric and hydrochloric acids and other chemicals used in the separation of cell wall fractions favor dehydration and condensation reactions, there is no reason to believe that such agents cause lignins to be formed from the carbohydrates of the cell wall. By the application of pre-extraction techniques, along with careful regulation of temperature and general chemical conditions (Brauns, 1952) (Norman, 1937), one may avoid entirely the formation of interfering substances. The formation of vanillin directly from the whole wood (Freudenberg, et al., 1940), and the isolation, by mild procedures, of small quantities of lignin chemically similar to all of the lignin obtainable verify the existence of lignin in the plant tissue.

The ultimate source of lignin must be a photosynthetically formed carbohydrate; it has been shown that $C^{14}O_2$ supplied to the plant appears quickly in the lignin fraction (Stone, 1953). Some investigators, however, have sought to associate lignins with one or another preformed carbohydrate fraction of the cell wall, or have postulated the formation of $C_6$-$C_3$ units by direct assimilation of $CO_2$. The latter hypothesis, held by Klason (1920), can neither be proven nor discredited at present. Although it is perhaps more reasonable to make use of existing carbohydrates, it remains possible for certain substances in the plant to be constructed from forms of assimilated carbon other than hexose. The workers who hold that lignin originates in a preformed wall fraction base this hypothesis on changes in wall composition during growth of the plant (see Griffoen, 1938, for example). Unfortunately, such proposals have been based on percentage changes rather than on absolute increase or decrease in various constituents. Obviously, if lignin undergoes a more rapid increase at some point in the life of the cell while other components remain constant, the percentage of lignin will appear to be increasing at the expense of other materials present. It is also possible that even absolute decreases in carbohydrate components may be associated with lignin formation only in the sense that the carbohydrates in question are returned to a common pool to be channeled into any active pathway. Therefore, except as they relate to the formation of aromatic precursors, theories dealing with the formation of lignins directly from cellulosic and other carbohydrate constituents of the plant are of historical interest only.

### *The Origin of Aromatic Precursors*

At present, cyclitols, reasonably derived from carbohydrates, can be regarded as possible intermediates in the formation of the aromatic nucleus (Davis, 1951; Geissman and Hinreiner, 1952; Birch, et al. 1953). Recently, Weiss, et al. (1954) presented evidence that the first benzenoid substance formed in *E. coli* is phenylpyruvic acid, readily formed by enzymatic or non-enzymatic means from a substituted cyclohexadiene, prephenic acid. Too little information exists to justify a discussion of aromatic biosynthesis in the present review, although it is an integral part of the problem of lignin formation. The review by Geissman and Hinreiner (1952), which deals with flavonoid synthesis, presents theories equally germane to the problem of lignin genesis. The fungus, *Lentinus lepideus*, has been found to convert the carbohydrate fraction of wood into methyl *p*-methoxy cinnamate, a compound similar to the structural units of lignins (DeStevens and Nord, 1953).

The methoxyl content of the lignins is one of their most distinguishing features. Among non-carbohydrate components of the plant, the methyl groups occurs almost exclusively in the N-methylated alkaloids, the O-methylated essential oil or other aromatic substances (eugenol, anisole, etc.), and the lignins, which we assume to be derived from the latter. Of these groups, the lignins are probably the largest single repository of non-labile methyl groups. Not only is the degree of methylation of lignins noteworthy, but so also is the pattern of methylation of lignins during maturation and aging of the cell. As has already been shown, the methoxyl content of some lignins increases dramatically during the development of the plant. It is not known whether this increase reflects an increasing methylation of the aromatic precursors of the lignin (for example, *o*-dihydroxyphenylguaiacyl), or of the first formed lignin itself.

In animals, the synthesis of methylated compounds is known to draw upon two reservoirs of labile methyl; the S—$CH_3$ of methionine, and the quaternary ammonium compounds such as betaine (Umbreit, 1952). Both formylation, with subsequent reduction, and direct transmethylation have been proposed as possible sources of methyl in plants (Geissman and Hinreiner, 1952), but it is only with the work of Byerrum and Flokstra (1952) that a definite experimental resolution of the problem has been provided. These investigators compared the fixation in lignin of $C^{14}$ supplied as $C^{14}H_3$ in methionine and $C^{14}OOH$ in formate. Their work shows clearly that the labelling of methyl groups of barley lignin was more extensive and more specific with methionine than with formate as the $C_1$ donor. It would appear that transmethylation may be the dominant process in this instance.

### *Condensation of Hydroxyphenylpropanes*

Eugenol and related substances readily form resinous condensation products when treated with alkali. These substances are frequently insoluble in neutral and acidic media, and in alcohols and other organic solvents as well. The nature of these condensation products depends greatly on the temperature and amount of alkali. Such condensation reactions are not limited to vigorous chemical conditions by any means; hydroxyphenylpropanes having an oxygen function or a double bond in the side chain have a strong tendency to undergo ortho- and para-nuclear condensations under mild conditions (Gortner, 1949; Geissman and Hinreiner, 1952).

A model satisfying many of the requirements indicated for a lignin molecule can be prepared from dehydrodiisoeugenol (Fig. 1) by further oxidation and methylation, forming Erdtman's acid. The formation of this dimer can be accomplished by purely chemical means but the initial condensation can also be carried out with preparations of oxidizing enzymes from mushrooms (Freudenberg, 1939). Dimeric substances formed from $C_6$-$C_3$ compounds are not of laboratory interest only; olivil, conidendrin, guaiaretic acid and similar resinous materials form a class of naturally-occurring aromatic compounds known as the lignanes. These compounds are of reasonably wide occurrence (Zygophyllaceae, Oleaceae, Myrtaceae, Compositae, Taxaceae and Pinaceae, and other families). They are believed to be formed by the condensation of eugenol or eugenol-like molecules (Geissman and Hinreiner, 1952), and Vanzetti (1936) has proposed that lignanes such as olivil may actually be regarded as intermediates in lignin formation, proceeding to higher degrees of polymerization under normal physiological conditions, and accumulating as lignanes only in pathological circumstances.

We have, then, sound chemical and biochemical bases for our belief that the phenylpropane

compounds under consideration are the most plausible materials to be brought forth as lignin precursors.

In 1952, Freudenberg et al. demonstrated that a semi-purified enzyme preparation obtained from young shoots of *Araucaria excelsa* could effect the conversion of coniferyl alcohol to a dehydrogenation polymer with some lignin-like properties. The enzyme preparation included peroxidase and phenol oxidases, and the yield of polymer (principally the dimer, diconiferyl alcohol) could be increased several fold by the addition of hydrogen peroxide. The reaction was carried out over a rather lengthy period of 2 to 4 weeks, with several additions of the peroxide during that time. Later, Freudenberg and Heel (1953) prepared hydroxycinnamyl alcohols and found them to be transformed into condensation products by a preparation of mushroom enzymes in 2 to 3 days. Of course, the polymers obtained from hydroxycinnamyl alcohols differ from lignins in their lack of methoxyl groups. In principle, as will be seen below, the methoxyl group is not a prerequisite for polymerization of phenylpropanes per se, but are only a characteristic of most lignins or their precursors.

Siegel (1953) incubated eugenol, other phenylpropanes, and various phenols with slices of embryonic hypocotyl from the Red Kidney bean, finding that, in the presence of $H_2O_2$, the phenylpropanes were converted into insoluble colored products within a few minutes. On the basis of color reactions, solubility, and isolation with 72 per cent sulfuric acid, these products were concluded to be lignin-like polymers. In further work (Siegel, 1954, 1955), the characteristics of the presumptive eugenol-lignin formed in *Elodea* stem slices and pea root sections were examined in detail and observations made on the conditions requisite to its formation.

The polymerization of eugenol was entirely peroxide-dependent. The localization of peroxidase, natural lignin, and the site of deposition of synthetic lignin were identical, being confined largely to vascular tissues. Although oxidation products of eugenol were formed in the cytoplasm, eugenol lignin was found only in cell walls, and washed cell wall fragments were found to be nearly as efficient as tissue slices in formation of lignin from eugenol. The wall-free cytoplasmic fraction, on the other hand, was almost totally ineffective in converting eugenol to lignin, although this phenol was readily oxidized by the peroxidase present.

Eugenol-synthetic lignin, eugenol itself, and the natural lignins of oak, pine, and spruce were compared by Siegel (1955). This comparison showed that the synthetic lignin was similar to all three natural lignins, and almost identical with spruce lignin. The elementary and group composition of eugenol lignin (C 63 per cent, H 7 per cent, $OCH_3$ 15 per cent) was very close to that for spruce: C 65 to 66 per cent, H 6 per cent, $OCH_3$ 15 to 16 per cent (Brauns, 1952). The ultraviolet absorption spectra for synthetic and natural substances were essentially superimposable. Hence, the peroxidative pathway for lignin synthesis has been established. The lignin synthesized on washed cell wall fragments was of somewhat different composition, being richer in oxygen and poorer in methoxyl that that formed in tissue slices.

There is reason to think that lignin formation, both as above from eugenol and in nature, involves the formation of reactive intermediates, possibly semiquinones, which actually undergo non-enzymatic condensation to form a variety of products including lignins (Adler and Lindgren, 1952; Siegel, 1955). The formation by peroxidase of several oxidation products from single pure substrates is known (Westerfield and Lowe, 1942; Siegel, 1955), and can best be explained on the assumption that a single, enzymatically formed intermediate can react with like molecules, or the reduced substrate, in a variety of ways.

A survey of 21 phenols for lignin-forming properties established that only hydroxyphenylpropanes such as eugenol, coniferyl alcohol and ferulic acid, could serve as precursors. The absence of a free hydroxyl group in the ring (cinnamic acid), and the blockage of an aromatic hydroxyl by methylation (eugenol monomethyl ether) or by glucosylation (Coniferyl alcohol-d-glucoside, coniferin) prevented peroxidative formation of lignin. The aglucone of coniferin was, however, released by pea root tissues, and the coniferyl alcohol polymerized to lignin if sufficient preincubation time was allowed. Two other phenylpropanes, melilotic acid (o-hydroxyhydrocinnamic acid) and thymol (1-methyl, 4-isopropyl, 3-hydroxybenzene), also were lignin precursors. Our present concepts require that melilotic acid be further hydroxylated to provide a 4-hydroxy compound, and the side chain either desaturated or an oxygen function introduced before conversion to lignin. Such a lignin, like the polymerized hydroxycinnamyl alcohols of Freudenberg, would be methoxyl-free. Thymol, a monoterpene,

is difficult to fit into the structural picture of the lignin precursor which we have been developing, principally because of the presence of the isopropyl side chain. Hence, consideration of its place in lignin genesis must be deferred until the detailed characteristic of the thymol polymer are established.

Freudenberg and Bittner (1953) have provided additional convincing evidence for the participation of phenylpropanes in lignin formation by demonstrating that the radioactivity of $C^{14}$-labelled coniferin sealed under the bark of a spruce tree could be recovered almost entirely in the lignin fraction.

An even later publication of Wacek et al. (1954) described the lignification of spruce phloem tissues induced by addition of one per cent coniferin to cultures in vitro. The phloem yielded no phloroglucinol color reaction for lignin initially and the development of a positive test after addition of the coniferyl alcohol glucoside failed in tissues which had been subjected to heating, freezing or chemical agents.

Both peroxidase and the phenolases have figured in the systems studied by Freudenberg. However, the transformation of eugenol to lignin can be effected only in the presence of peroxide. Potato tuber tissue, with its high tyrosinase content and low level of peroxidase activity, can transform eugenol to lignin only with the addition of $H_2O_2$. Although application of mushroom oxidases to the problem of lignin synthesis must be regarded with great interest, it must be treated primarily as a preparative method rather than as an attempt to simulate the natural process of lignification. Presumably several oxidizing enzymes, including phenolases and peroxidases, can participate in the condensation of phenylpropanes to lignins, and the relation between precursor and the enzyme may be no more than a question of substrate specificity.

Recent investigations carried out at the California Institute of Technology by A. W. Galston, W. A. Jensen and the author have been concerned with an induced (adaptive) form of peroxidase present in root tissue. These studies, incorporating the histochemical approach, establish further a relation between vascular differentiation, lignification and peroxidase. The peroxidase activity of the *Vicia* root, for example, exhibits a high point located well behind the general meristem and just apical to the site of protoxylem and protophloem formation. Treatment of root tissues with 3-indoleacetic acid (IAA) induced a peroxidase to form with an apical shift in the peroxidase peak. The latter finding is consistent with the generally accepted vascularization of roots after exposure to IAA or synthetic growth regulators.

In exploring further the peroxide requirement for polymerization of eugenol, Siegel found that approximately 2 moles of $H_2O_2$ were consumed for each mole of eugenol oxidized by pea root tissues, but that this included oxidant was required for the formation of both lignin and other products, possibly of a lower degree of polymerization. There is now good reason to believe that plant tissues form adequate amounts of peroxide, both through conventional flavoprotein and non-flavoprotein pathways to support such peroxidative processes as lignification (Siegel and Galston, 1955). In addition, non-enzymatic pathways for peroxide genesis include photochemical processes (Rabinowitch, 1945) and the autoxidation of phenolic materials such as guaiac resin (Maehly and Glick, 1954). The enhancement of peroxide formation by light may explain the effect of illumination described earlier on natural lignin formation.

It is perhaps of significance that biological systems have many ways of regulating peroxide levels, hence the intensity of peroxide-consuming reactions. Omitting the pathways of peroxide genesis, mention may be made of thiols such as cysteine, phenols other than lignin precursors, ascorbic acid, and heavy metal ions of lower oxidation number ($Fe^{II}$, $Mn^{II}$). These are substances which are able to react readily with $H_2O_2$, and hence remove it. The extent to which these and other factors control the peroxide "reservoir" in the cell merits further study.

In conclusion, it may now be said that the long postulated role of phenylpropanes in lignin formation is proven. Principally, derivatives of p-hydroxyphenylpropane are required as lignin precursors, and these may be transformed by peroxidases or other phenol oxidizing enzymes into polymers with the chemical and physical properties of lignins. The polymerization seems to be slow in cell-free systems, rapid in the presence of cells or cell wall fragments. Although the details of lignification as a physiological process are still essentially unknown, we are now in possession of model systems from which the details of lignin synthesis can be derived and the course of future experimentation directed.

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# THE PROBLEM OF CEROPHAGY OR WAX-EATING IN THE HONEY-GUIDES

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## INTRODUCTION

IN THESE days of great specialization within the biological sciences, it is all too rarely that a problem in one branch arises directly out of observations in another, superficially quite unrelated one. That this does occur, is, however, significant as a reminder that all of biology is a related whole, and also as a corrective to the tendency to spin out the threads of any one specialty to the point where all relation to total biological reality becomes very tenuous. At first glance it might seem that a problem in animal behavior and a study of microbiological metabolism were mutually remote, but the facts are otherwise, as will be shown in the present paper. Furthermore, one cannot avoid a feeling that a problem growing out of the much maligned "natural history" aspect of biology may have a reality of a different sort from one emanating from the library and the armchair of the technical specialist.

The honey-guides, a small family of birds related to the woodpeckers and the barbets, comprise eleven species, classified in four genera. All but two of these eleven occur only in Africa south of the Sahara, while the other two are Asiatic, one in the Himalayas and one in the forests of Malaya, Sumatra, and Borneo. Few families of birds present more puzzling problems to the student of animal behavior, inasmuch as the honey-guides are parasitic in their breeding habits, and because one section of the family has developed a most remarkable symbiotic relationship with certain mammals—ratels and human beings—a relationship that has given the birds both their common name of honey-guides and their technical one (*Indicatoridae*). In effect, the birds guide or lead these associates to the near vicinity of wild bees' nests, then wait there for them to open the hives, and finally the birds feed on the bits of bee comb left strewn about by their mammalian foraging symbionts.

Until recently, the impression one received from the literature was that the honey-guides fed largely, if not wholly, on bee comb and its inclusions (bee larvae, eggs, and honey), but that the birds could not open the wild bees' nests by themselves and therefore had to depend on the aid of ratels and humans, which they "guided" to these potential stores of food. In other words, guiding was thought to be the chief food-getting method used by the birds. To the thoughtful student of animal habits this posed a disturbing problem. Habits, like structures, have their long and involved evolutionary history, a history which can be reconstructed mainly on the evidence for "selective values" in their successive stages. But a habit such as this, whose only apparent use to the bird depends entirely on the cooperation of two wholly separate and independent creatures (bird, and ratel or human) cannot have had any conceivable value until it was perfected by both participants, and perfected in such a way as to be of benefit to the bird. Incipient or intermediate stages in its development would seem to have been quite useless; it was an "all or nothing" situation. It followed that either the literature was misleading and that the picture of the guiding habit was wrongly expressed, or that there was more to it than just the matter of food-getting. As the result of extensive studies in the field by Friedmann (1955), it is now known that this guiding behavior, which looks so purposive, is actually a form of excitement reaction on the part of the bird when meeting with a potential foraging symbiont, and that the excitement dies down when the bird, with its symbiont near at hand, sees or hears swarming bees. Inasmuch as this happens chiefly at or near a wild bees' nest, the result usually is that the bird and its follower have come to a

bees' nest, or, from the standpoint of the symbiont, to a source of honey. Ordinarily the bird does not "lead" in a straight line to the bees' nest, but goes through its noisy performance from tree to tree in a most circuitous route, and may even "back track" occasionally. The evidence further reveals that it is not necessary for the bird to know in advance the location of the bees' nest which eventually becomes the stopping place, the apparent "goal" of the guiding trip.

It may be worth while to give here a brief description of what constitutes typical guiding behavior (ex Friedmann 1955, pp. 32–33).

When the bird is ready to begin guiding it either comes to a person and starts a repetitive series of churring notes or it stays where it is and begins calling these notes and waits for the human to approach it more closely. These churring notes are very similar to the sound made by shaking a partly full, small matchbox rapidly lengthwise. If the bird comes to the person to start leading him, it flies about within 15 to 50 feet from him, calling constantly, and fanning its tail, displaying the white outer rectrices. If it waits for the potential follower to approach it for the trip to begin, it usually perches on a fairly conspicuous branch, churring rapidly, fanning its tail, and slightly arching and ruffling its wings so that at times its yellow "shoulder" bands are visible. As the person comes to within 15 to 50 feet from it, the bird flies off with an initial conspicuous downward dip, with its lateral rectrices widely spread, and then goes off to another tree, not necessarily in sight of the follower, in fact more often out of sight than not. Then it waits there, churring loudly until the follower again nears it, when the action is repeated. This goes on until the vicinity of a bees' nest is reached. Here the bird often (usually, in my experience) suddenly ceases calling and perches quietly in a tree nearby. Some observers record no such cessation of the churring notes when near the bees' nest, but all agree that the bird perches unobtrusively in a nearby tree or shrub and there waits for the follower to open the hive, and it usually remains there until the person has departed with his loot of honeycomb, when it comes down to the plundered bees' nest and begins to feed on the bits of comb left strewn about. The time during which the bird may wait quietly may vary from a few minutes to well over an hour and a half.

The guiding habit naturally made one wonder what it really was that was behind the birds' interest in bees' nests, and this question was only accentuated by continual observations of the birds feeding extensively on insects which they pursued and caught largely on the wing, after the manner of our flycatchers. Detailed studies of the birds in the field, coupled with critical compilations of the observations and notes of other observers, may now be said to have demonstrated that the basic, primary interest of the honey-guides in the bees' nests is in the wax of the comb, and not, as formerly assumed, the honey, stored pollen, or the bee larvae. The discovery that wax was the substance the birds wanted, and what they ate avidly and in great quantity, naturally raised the question as to what they could get out of this material, generally regarded as non-nutritive, and as to how they managed to do so, as wax was thought to be indigestible, at least to higher animals. Even though the birds consumed great numbers of insects as well, the wax was a prominent part of their diet. The phenomenon of wax-eating, or cerophagy, thus presented a definite extension of the materials involved in the field of animal nutrition, and also an intriguing problem in the mechanics of digestion. Furthermore, as a background thought, one could not ignore the possibility that any information as to the methods employed in the digestive splitting of beeswax into fatty acids of simple enough structure to be assimilable by the birds might eventually prove useful in the medication of certain human diseases, the causative organisms of which were fairly protected from ordinary enzymes by a waxy envelope.

Prior to the new information on the honey-guides, the only animal known to eat beecomb was the waxworm, the larval stage of the wax moth (*Galleria mellonella*), which at times becomes a serious pest to apiculturists because of the damage it does to domestic bee hives. The literature concerned with the metabolism of beeswax is practically restricted to this lepidopteran, but there are also some studies available on the changes brought about in beeswax, paraffin, and other hydrocarbons by bacteria, yeasts, and molds.

Unfortunately, the available information concerning the metabolism of beeswax by *Galleria* larvae is somewhat confusing. Florkin, Lozet, and Sarlet (1949) isolated from the intestinal tract of the larvae a bacterium which utilized beeswax

and produced acid in the medium. Dickman (1933) found several such organisms which produced "active substances" causing marked changes in the beeswax substrate in vitro. However, Wollmann (1911) had shown earlier that larvae raised aseptically could still utilize beeswax. In addition, several investigators, *viz.*, Duspiva (1935), Fiessinger and Gajdes (1936), and Mankiewiez (1949), have demonstrated the existence of either lipolytic or "cerolytic" enzymes in extracts prepared from *Galleria* larvae; no evidence for the involvement of microörganisms was presented by any of these investigators.

The mold, *Aspergillus flavus*, was shown by Taussen (1928) to be capable of utilizing beeswax as a source of carbon. He demonstrated that yeasts and yeast-like organisms which could be isolated from the soil metabolized paraffin and beeswax. An organism resembling *Micrococcus ureae* was shown to metabolize beeswax by Heitzmann and Bouchard (1949) in studies conducted in the Warburg respirometer. However, the degree to which the components of the wax were utilized was not determined.

In the preliminary studies of wax digestion by the honey-guides reported earlier (Friedmann, 1955), determinations were given of the melting points of wax from beecomb, from the gizzard, intestines, and the droppings of honey-guides, kindly made by Dr. Albin H. Warth, and also similar determinations of the saponification values of these samples made by Dr. F. P. Veitch, of the University of Maryland. These indicated so clearly that the ingested wax was profoundly changed during its passage through the bird's alimentary tract, that it was felt that the whole problem was worth investigating further. It is the results of this further study that we are presenting here for the first time.

## METHODS AND MATERIALS

Unless otherwise specified, the birds used were of one species, the lesser honey-guide, *Indicator minor*.

*Maintenance of birds.* Upon arrival from Africa the birds were routinely kept on a diet of either wild or domestic beecomb, mealworms, and water. The crushed comb was fed to the birds ad libitum in individual, small parakeet cages which were kept in the animal room at approximately 25°C. The birds were examined each day for their general appearance, i.e., ruffling of feathers, drooping head, difficulties in perching, and other physical manifestations of dietary deficiency.

*Collection of droppings for microbiological and chemical assay.* For the purpose of identifying the microbial flora, droppings were collected on clean towels which were placed in cages approximately 30 minutes prior to collection. The excreted material was thoroughly suspended with the aid of several glass beads in 10 ml. of sterile physiological saline contained in a 25 ml. Erlenmeyer flask. This material was either used immediately or kept frozen at −40°C. prior to use.

For chemical analysis, where aseptic techniques were not required, the droppings from each bird were collected for a period of days, pooled in screw-cap test tubes, and refrigerated at 4°C. prior to use. Collection on a number of consecutive days from the same birds was necessary in order to accumulate enough material for chemical analysis.

*Determination of saponification numbers.* Saponification numbers were run on unaltered beeswax, myricyl palmitate, the intestinal contents of dead birds, and excreted bird droppings, using the method described by Warth (1947). The material to be analyzed was first continuously extracted with either chloroform for 10 hours or with benzene for 6 hours in the Soxhlet apparatus. By this procedure materials of a lipid nature only are extracted. The extracted material was brought to dryness by slowly evaporating the solvent on a hot plate with a slow stream of air blowing over it. Saponification numbers were determined on such extracted materials.

*Metabolic studies.* To obtain large amounts of cells for metabolic studies, the desired microbes were grown in 15 liters of trypticase soy broth in 20-liter carboys with constant aeration for 24 hours at room temperature. After the incubation period, the cells were centrifuged in a Sharples apparatus, washed with distilled water, and either used immediately, stored in the icebox for 24 to 48 hours, or broken up to obtain cell-free preparations. It may be explained that the Sharples centrifuge is an apparatus employed when large volumes of media are to be centrifuged for the collection of bacterial cells. Extracts were prepared by grinding the cells with Alumina 303 powder (McIlwain, 1948), a finely powdered aluminum oxide which breaks the cells by abrasive action. The grinding was done in the following manner: a large mortar, previously chilled to

−20°C., was evenly lined with a known weight of cells. This procedure immediately freezes the bacteria against the walls of the vessel. An equal amount of Alumina 303 powder was now added and mixed with the frozen cells by scraping the latter off the sides of the mortar with a spatula. The mixture of powder and cells was triturated until a rather thick, creamy mass was obtained. The cell paste was diluted (with trituration) four-fold with distilled water, allowed to stand 5 to 10 minutes, and centrifuged at low speed to remove cell debris and alumina powder. To obtain translucent extracts, the supernatant solution was centrifuged twice at approximately 12,000 r.p.m. Protein values ranged from 20 to 30 mg. per ml. The supernatant extracts obtained by this procedure are extremely viscous, so as to make subsequent ammonium sulfate fractionations extremely difficult. It has been found in this laboratory that this difficulty can be obviated in the following manner by the addition of small amounts of desoxyribonuclease (DNAase), a substance that decreases the viscosity of the preparation by hydrolyzing the nucleic acids in the total extracts, but that does so only in the presence of magnesium. Approximately 500 micrograms ($\mu$g.) of DNAase powder are stirred into 100 ml. of extract previously adjusted to 0.001 *M* with respect to $MgCl_2$. The extract is incubated at 0°C. until the viscosity is decreased to a minimum, as determined by the rate of flow from a 0.2 ml. serological pipette. The extract thus obtained is next fractionated at 0°C. to 3°C. by slowly adding the requisite amounts of ammonium sulfate with constant stirring. The protein precipitate obtained at the desired salt concentration is centrifuged off, redissolved in distilled water, centrifuged again to remove any insoluble material, and kept frozen prior to use.

In some instances cell-free extracts were prepared by grinding the bacterial cells with ground glass, according to the procedure originally described by Kalnitsky, Utter, and Werkman (1945).

The respiratory activity, i.e., $O_2$ uptake and $CO_2$ evolution of living but non-proliferating or of resting whole cells as well as cell-free extracts on a variety of waxy materials was measured in the conventional Warburg-Barcroft respirometer. Quantitative lipase activity of crude and partially purified preparations was likewise measured in the Warburg in the following manner: the substrate, tributyrin, was incubated in the presence of a bicarbonate buffer and enzyme. As butyric acid is liberated (as a result of lipase activity) the *p*H of the incubation mixture is lowered, and a proportionate evolution of $CO_2$ results. The volume of the evolved gas can be measured accurately and functions as an index of lipolytic activity (Rona and Lasnitzki, 1926). Lipolytic activity of actively growing isolates was detected on beef-infusion-nile-blue-triglyceride agar (Turner, 1929).

The waxy materials were prepared for metabolic experiments as follows. Beeswax, myricyl palmitate, tubercle wax, cerotic acid, and palmitic acid were first frozen at −40°C. and then ground with mortar and pestle to a fine powder. In all cases a known quantity of each of these materials was added to the requisite Warburg vessels. Tributyrin, a liquid, was shaken vigorously with 0.067 *M* sodium bicarbonate, and a known quantity of this mixture used.

## EXPERIMENTAL RESULTS

*Life span of the honey-guide in captivity.* Thus far the average life span of the adult honey-guide in captivity when maintained on a diet of domestic beecomb, mealworms, and water was found to be approximately 23 days, with a minimum of 18 days and a maximum of 27 days. This statement does not apply to birds under special experimental conditions, or to birds which were received in poor condition. It should be pointed out that the diet given the birds was a partial one, and not a complete or natural one. In a wild state the birds consume quantities of insects of many kinds, as well as beecomb. The latter is sought for its waxy content, but bee larvae are picked out and eaten, and quantities of honey and pollen are also ingested, even if only adventitiously. During the 18 to 27 days of maintenance, each bird consumed approximately 10 grams of beecomb per day, very few of the mealworms, and considerable amounts of distilled water. Since the birds did not seem to care for the mealworms, in later experiments this food item was omitted. It was originally given the birds as a substitute for the insects they would normally have eaten in the wild state. These mealworms are used very successfully for a great variety of insectivorous birds in the National Zoological Park, in Washington, D. C.

During the early states of captivity the birds

exhibited no obvious signs of sickness and appeared normal in all respects. Around the 14th to 16th day, the neck feathers began to ruffle and difficulty in perching began. By the 25th day the birds looked considerably weakened and emaciated, although they continued to nibble at the wax. Perching usually ceased around this time, and death followed within 24 to 48 hours. Upon autopsy the birds were found to be considerably emaciated, with the gizzard very much distended and filled with waxy material. It appeared that the anal opening was "plugged" with semi-digested wax.

*Determination of saponification numbers.* To elucidate more fully the changes which occur in the waxy materials during their passage through the birds' alimentary tract, as previously reported by Friedmann (1955), additional samples were studied. The saponification numbers were determined on the wax from unaltered beecomb and the wax obtained from the droppings, as well as from the material of the intestinal tract. The results are shown in Table 1. It is readily apparent that there is a progressive increase in the saponification number of the wax in the course of its passage through the alimentary tract of the honey-guide. Since the magnitude of the saponification number serves as an index of the concentration of the free fatty acids contained in the wax, it is quite clear from the data presented that a significant chemical change occurred in the wax after it had been ingested by the birds.

*Survival of birds on myricyl palmitate.* With as complex a mixture as beeswax, it is exceedingly difficult to determine which chemical entity of the substance provided the necessary nutrient to maintain the birds for as long as several weeks. An attempt in this direction, however, was made by a feeding experiment in which individual birds were each supplied with but one of the major components of beeswax, and the length of time they survived on this partial diet was recorded. It was found that birds which were kept on a diet of myricyl palmitate, mealworms, and water survived for a period of 13 days. The birds that were kept on either neutralized palmitic or cerotic acids died within 24 hours. As a matter of fact the birds refused to nibble at the cerotic acid at all. The control bird in this experiment, which was fed beecomb, survived 18 days. Since we have found that birds supplied with water only survive a maximum of 48 hours, these results would suggest that myricyl palmitate, which constitutes the largest single component, by bulk, of domestic beecomb, might indeed be at least one of the essential nutrients which the honey-guide receives by breaking down the wax.

In order to determine whether the ingested myricyl palmitate was in any way transformed while passing through the intestinal tract of the birds, saponification numbers were run periodically on the chloroform-extracted droppings from this honey-guide. The results are shown in Fig. 1. It is apparent that the ester has undergone considerable alteration, since the saponification

TABLE 1

*Saponification numbers of wax before and after ingestion*

| SOURCE OF WAX | SAPONIFICATION NUMBER |
|---|---|
| Unaltered beecomb (control) | 82.8 |
| Gizzard of honey-guide | 101.3 |
| Droppings of honey-guide | 177.1 |

Saponification values shown represent averages of two determinations from each source.

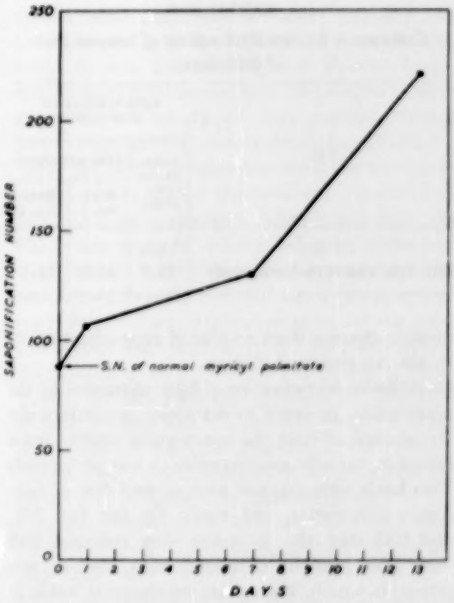


FIG. 1. CHANGES IN INGESTED MYRICYL PALMITATE

TABLE 2

*Comparison between lipid content of beecomb and of droppings*

| DAY | LIPID CONTENT IN PER CENT OF | | |
|---|---|---|---|
| | UNALTERED BEECOMB | BIRD DROPPINGS | |
| | | Bird No. 1 | Bird No. 2 |
| 0 | 75.8 | — | — |
| 3rd, 7th, and 10th (combined) | 75.8 | 29.8 | 31.1 |

number changes from a value of approximately 90 to 226 in a period of 13 days.

***Quantitative determination of lipid utilization by the honey-guide.*** In order to determine quantitatively the amount of lipid the honey-guide utilizes from beecomb, the following experiment was performed. Two birds were exposed to a normal diet of beecomb, mealworms, and water. On the 3rd, 7th, and 10th day, the droppings were collected and their lipid content compared with that of unaltered beecomb. The results are shown in Table 2. It is clear that the total lipid content of the beecomb decreased by more than half after passage through the alimentary tract of the birds. Total lipids were determined by extracting beecomb or droppings with chloroform and drying the extracted material (after removal of the solvent) in a desiccator, and weighing the dried lipid. This experiment further proves that a considerable portion of the lipid contained in the beecomb was actually utilized by the honey-guides.

***Microbiological studies.*** Having definitely established that (1) the lesser honey-guide can survive on a diet consisting of essentially nothing but beecomb, and (2) that the lipid content of the beecomb is both reduced and the remainder chemically modified while passing through the alimentary tract of the birds, experiments were initiated in an effort to ascertain the mechanism by which this change occurs. Two possibilities were apparent, either that the microbial flora in the intestine, or that some enzyme contained within certain tissues of the bird, brings about these changes. A series of microbiological studies was thus initiated in order to investigate the first of these two possibilities.

A heterogeneous group of microorganisms was isolated and identified from droppings of the honey-guide, as listed in Table 3. Microorganisms were not isolated from the intestinal tract of the bird, since it is well known that almost immediately upon death the microbiological flora of animals changes and no true representative flora could thus be obtained. Previously (Friedmann, 1955) a number of organisms were isolated and identified by Cowley and Warren from cultures made from the intestinal tract of a dead bird sent from Africa by Dr. Büttiker. In the present study, in order to assure isolation of all possible flora, various enrichment media were used. These included sheep blood agar, rabbit blood agar, trypticase soy agar, and veal infusion agar. For the isolation of anaerobes, cooked meat and fluid thioglycollate media were utilized, and incubation was carried out under anaerobic conditions. Classification was based on comparison of observed morphological and biochemical characteristics with those listed in the latest (1948) edition of Bergey's *Manual for Determinative Bacteriology*. It is to be noted that not all of the organisms listed were always isolated from droppings of different birds. As a matter of fact, only two microbes were consistently found on every isolation. These included (1) an organism belonging to the genus *Micrococcus*, and (2) a strain of yeast identified by the present authors as well as by Dr. R. Benham of Columbia University as *Candida albicans*, also referred to as *Monilia albicans*.

TABLE 3

*Microorganisms isolated and identified from droppings of the honey-guide*

*Micrococcus caseolyticus*
*Micrococcus* sp.
*Achromobacter liquefaciens*
*Achromobacter* sp.
*Escherichia coli*
*Escherichia intermedium*
*Aerobacter aerogenes*
*Bacillus cereus*
*Bacillus* sp.
*Pseudomonas ambigua*
*Paracolobactrum* sp.
*Pseudomonas* sp.
*Candida albicans*

In addition to these, Friedmann (1955) reported the following, from cultures made from the intestinal tract of a greater honey-guide (*Indicator indicator*) in Rhodesia, by Dr. W. Büttiker, and identified by Dr. Joel Warren and Major R. Cowley.

*Pseudomonas cutirubrum*
*Bacillus firmus*

The coccus could not be further identified since its characteristics did not conform to any one known species in the genus *Micrococcus*. It is apparently a hitherto unknown species and will be named and described in another paper.

In studying the metabolic activities of all of these isolates, the initial interesting observation was made that out of all of the organisms found and tested only the *Micrococcus* and the *Candida* exhibited lipolytic activity. In the case of the latter two species, blue zones of several millimeters in diameter appeared in 24 to 48 hours incubation on nile blue agar. The blue zone on this medium is an indication of the existence of a lipolytic enzyme elaborated by a microorganism. The esterase of the microbe hydrolyzes the ester in the medium, so as to produce an acid, which, in turn, alters the *p*H of the medium surrounding the colony, and changes the indicator nile blue to a deep blue color. These zones, which have been shown by Turner (1929) to represent indices of lipolytic activity, continued to increase in size for about 7 days, after which time the zones remained constant. Because of their lipolytic activity and the regularity with which they occurred in the droppings, all further microbiological work utilized only the yeast and the *Micrococcus*.

The presence of the *Micrococcus* and the *Candida* in all the birds raised the question as to how and where the latter acquire them. Since birds obviously cannot inherit their microorganisms, it follows that they have to pick them up. Inasmuch as the honey-guides are parasitic in their breeding, like some of the cuckoos of the Old World, the young have no contact with their parents (which already have the microorganisms) and receive no wax in the food given them by their foster-parents. The most likely source for these microbes then, seemed to be wild beecomb; and, accordingly, samples of wild African comb were cultured and were found to harbor the *Micrococcus*. We have not yet been able to obtain nestling honey-guides, as yet without contact with wax, to ascertain whether the lipolytic microbes are absent from their intestinal tracts. It is hoped to fill this gap in the evidence before long, and plans have been formulated to this end. The *Micrococcus* appears to be peculiar to wild African beecomb, and has not been found in samples of domestic American comb which have been tested.

*Lipolytic activity of Candida albicans.* Detailed studies were performed in order to learn the behavior of the isolated yeast on wax. In this work the wax slide technique of Florkin, Lozet, and Sarlet (1949) was applied. Thoroughly cleaned glass slides were dipped into purified, molten beeswax and the wax-filmed slides placed each in a sterile petri dish. A culture of the yeast was inoculated into the cooled film and was incubated at 37°C. in a moist chamber. After 5 to 7 days, the films were carefully peeled from the slides and either stained with dilute alkaline methylene blue or observed directly with the aid of phase microscopy. It was found that vegetative hyphae grew throughout the wax film in the area adjacent to the inoculum site. These were visible both in stained and unstained preparations. A photograph of such a preparation is shown in Fig. 2. These results suggest that this strain of *Candida albicans* can grow in a wax medium. The source of nitrogen under the conditions of the experiment is not apparent. However, it is well-known that some yeasts will grow with minimal amounts of nitrogen and some such small amount of nitrogen could have been present even in the purified wax that was supplied. In this connection it might also be argued that small amounts of carbohydrate could have been present in the wax and thus have supplied a carbon source for the yeast. However, this possibility was investigated and discarded,

FIG. 2. *CANDIDA ALBICANS* GROWING ON A WAX FILM

TABLE 4

*Metabolic activity of the* Micrococcus *on lipids*

| SUBSTRATE | $O_2$ UPTAKE ($\mu$l.) |
|---|---|
| Beeswax | 947 |
| Tubercle wax | 0 |
| Myricyl palmitate | 652 |

Each cup contained 50 mg. of substrate prepared as described in the section on methods; 1.5 ml. of 0.05*M* phosphate buffer, pH 7.4; 1.0 ml. of a 0.5% suspension of cells with 0.3 ml. of 4*N* NaOH in center well. Total volume 3.0 ml.; temperature 33°C.; time of incubation, 30 hours.

since microcarbohydrate tests revealed that purified wax was completely free of carbohydrate-like materials.

*Metabolic studies.* The lipolytic activities of proliferating or actively growing *Micrococcus* and *Candida albicans* prompted an investigation of their behavior in the non-proliferating or resting state, in which state their metabolism on a single substrate could be studied in an accurate, quantitative manner. Washed, resting cells of the *Micrococcus* were shown to metabolize beeswax and myricyl palmitate. No activity could be demonstrated with tubercle wax as substrate. The tubercle wax was prepared according to a modification of the procedure described by Anderson (1929), and was supplied to us by Dr. George Lohnes, of the National Institutes of Health, Bethesda, Maryland. The results are expressed in terms of microliters ($\mu$l.) or micromoles ($\mu$M.) of oxygen uptake and are shown in Table 4. The oxygen is consumed, both with beeswax and myricyl palmitate as substrates, rather slowly and continuous for some 30 hours. Endogenous activity, i.e., the activity exhibited by the microbes in the absence of externally added substrate, was relatively high at the start of the experiment, but dropped off sharply after one or two hours. The values shown in Table 4 were corrected for endogenous oxygen uptake. Several of the other isolates have been likewise tested for their ability to utilize these substrates, and in no instance have any positive results been obtained. Although resting cell suspensions of *Candida* did not metabolize myricyl palmitate, they did, however, show considerable activity on the tubercle wax and on beeswax. The results are shown in Table 5. In one hour of incubation considerable activity

TABLE 5

*Metabolic activity of* Candida *on lipids*

| SUBSTRATE | $O_2$-UPTAKE ($\mu$l.) |
|---|---|
| Beeswax | 96 |
| Tubercle wax | 48 |
| Myricyl palmitate | 0 |
| Cerotic acid | 0 |
| Palmitic acid | 0 |

Each cup contained 50 mg. of substrate; 1.5 ml. of 0.05*M* phosphate buffer, *p*H 7.4; 1.0 ml. of a 0.5% suspension of cells and 0.3 ml. of NaOH in the center well. Total volume, 3 ml.; temperature 33°C; time of incubation, 60 minutes.

was apparent. Another yeast, *Saccharomyces cereviseae*, used as a control in this experiment, showed no activity on any of the waxes. Neither the *Micrococcus* nor the *Candida* metabolized several other known constituents of beeswax, as shown in the table.

*Esterase activity of the Micrococcus.* The esterase activity of the *Micrococcus* was also investigated. Washed cell suspensions of this organism were exposed to a series of fatty esters in Warburg vessels in the presence of bicarbonate buffer. The evolved $CO_2$, which is due to the hydrolysis of the ester (which liberates acid), becomes a measure of the esterase activity. The results are shown in Table 6. It is apparent that tributyrin is the only substrate (of the several tested) that this organism will attack. Lipase or esterase activity

TABLE 6

*Substrate specificity of the esterase activity of* Micrococcus

| SUBSTRATE | $CO_2$ EVOLUTION ($\mu$l.) |
|---|---|
| Tributyrin | 496 |
| Triolein | 0 |
| Tripalmitin | 0 |
| Beeswax | 0 |
| Myricyl palmitate | 0 |
| Tubercle wax | 0 |

Each cup contained either 100 $\mu$M. of the various esters or 50 mg. of the solid waxes; 300 $\mu$M. of bicarbonate buffer, *p*H 7.9; 1.0 ml. of a 0.5% suspension of cells and distilled water to a final volume of 3.0 ml. The gas phase consisted of a mixture of 95% $N_2$ and 5% $CO_2$; temperature, 37.4°C; time of incubation, 60 minutes.

TABLE 7

*Combined lipase activity of* Candida albicans *and the* Micrococcus

| ORGANISM | CONCENTRATION OF CELLS | $CO_2$ EVOLUTION IN $\mu$M. | |
|---|---|---|---|
| | | Experiment 1 | Experiment 2 |
| *Micrococcus* | 1 ml. 5% susp. | 4.09 | 3.64 |
| Yeast | 1 ml. 5% susp. | 14.64 | 10.82 |
| *Micrococcus* plus yeast | 0.5 ml. 5% susp. each | 19.52 | 14.65 |

Each vessel contained the requisite amount of cells; 50 $\mu$M. of tributyrin, 0.5 ml. of 0.067*M* bicarbonate buffer, *p*H 7.9. Gas phase—95% $N_2$ and 5% $CO_2$; temperature, 37.4°C.; time, 60 minutes.

could not be demonstrated by this method with beeswax or substrate even when emulsifying agents such as gum acacia or methyl cellulose were used in its preparation. This apparent discrepancy can be explained by the fact that esterase activity is strictly a function of the liberation of an acid, whereas oxygen uptake might be due to the oxidation of a substance at any point.

Resting cell suspensions of the yeast likewise exhibit esterase activity on tributyrin. In this connection, it was interesting to note that a 1:1 mixture of yeast and micrococci was twice as active on tributyrin as an equivalent amount of each organism alone. In other words, 1 ml. of a 5 per cent suspension of the *Micrococcus* (see Table 7, Exp. 1) liberates approximately 4 $\mu$M. of $CO_2$; a similar concentration of yeast causes the evolution of 14.6 $\mu$M. of the gas; thus the amount of $CO_2$ expected to be liberated by a combination of the above two concentrations of cells should be the sum of 4 + 14.6, or 18.6 $\mu$M. A combination of one half of the concentration of each suspension should yield one half of 18.6, or 9.3 $\mu$M. Instead, 19.5 $\mu$M. of $CO_2$ were liberated. These data would seem to suggest that a close synergism exists between the two organisms, that is to say, when combined these organisms produce an effect that neither one is capable of producing when present alone.

*Lipase activity of acetone powders and cell-free extracts.* As a preliminary study in connection with the purification of the lipase from the *Micrococcus*, acetone powders as well as extracts of the organisms were studied for their activity on tributyrin. Acetone powders were used to dry the bacteria and to change their permeability so that cell materials might be extracted more readily with water. It was found, as shown in Table 8, that water extracts of acetone-dried cells exhibit appreciable lipase activity. That the reaction is enzymatic is indicated by the fact that heated extracts exhibit almost no activity. Likewise, cell-free extracts obtained by either glass or alumina grinding were likewise active. The activity appears to be distributed in the protein fraction precipitable between 0.4 and 0.7 ammonium sulfate saturation. Further studies on the purification of the lipase are now in progress.

*Lipolytic activity of honey-guide tissue.* The preliminary experiments thus far described would

TABLE 8

*Fractionation of the lipase from the* Micrococcus

| EXPERIMENT | PREPARATION | $CO_2$ EVOLUTION ($\mu$L.) |
|---|---|---|
| 1 | Extract from acetone-dried cells | 57.7 |
| | Heat-inactivated extract | 19.0 |
| | Endogenous | 13.0 |
| 2 | Extract from glass-ground cells | 774.0 |
| | Extract from alumina-ground cells | 186.0 |
| | | 186.0 |
| 3 | Ammonium sulfate fraction | |
| | 0.0–4.0% saturation | 3.0 |
| | 4.0–5.0% saturation | 60.0 |
| | 5.0–6.0% saturation | 90.0 |
| | 6.0–7.0% saturation | 70.0 |
| | 7.0–9.0% saturation | 4.0 |

Each vessel contained 100 $\mu$M. of tributyrin in 0.067*M* bicarbonate buffer, *p*H 7.9, the requisite amount of enzyme and distilled water to volume. Gas phase, 95% $N_2$ and 5% $CO_2$; temperature, 37.4°C.

Experiment No. 1. 75 mg. of acetone-dried cells were extracted with 3 ml. of distilled water, and the total extract was used immediately. Time of inoculation, 60 minutes.

Experiment No. 2. 2 ml. of extract were used. Time of inoculation, 90 minutes.

Experiment No. 3. 2 ml. of the respective fractions were used. Time of incubation, 30 minutes. In this experiment the ammonium sulfate fractionation was carried out by the addition of the requisite amount of the salt in the cold with constant stirring. The formed precipitates were centrifuged off, taken up in equivalent amounts of distilled water, dialyzed for 24 hours, and used.

seem to indicate that microbes are involved in the digestion of the wax by the honey-guide. The possibility that the avian tissues might show some lipolytic activity has been explored, and thus far the tests have yielded negative results. It is to be noted that in each instance tissues from dead birds were employed, and consequently the conclusions to be drawn are not wholly definitive.

***Further studies implicating microbes in the digestion of wax by the honey-guide.*** A series of experiments were conducted where birds were "sterilized" with an antibiotic and their survival time studied. The rationale of these studies was that if birds which have received an antibiotic will not survive as long as birds without antibiotic treatment, the tentative conclusion would be that microbial flora are indeed responsible, at least in part, for the digestion of the wax in beecomb by the bird. Accordingly, experiments were first performed in order to determine the sensitivity of the *Micrococcus* and *Candida* to one antibiotic and one chemotherapeutic agent, neomycin and sulfathalidine, respectively. The results presented in Table 9 show that while both organisms are sensitive to sulfathalidine, and the *Micrococcus* is sensitive and the *Candida* insensitive to neomycin, the concentrations of these antibiotics are to be taken into consideration. Clearly, the *Micrococcus* is highly sensitive to neoymycin, since as little as 1 μg. per ml. is sufficient to prevent any growth of this bacterium. On the other hand, relatively large concentrations, namely, 5 mg. per cent of sulfathalidine, are required to prevent the growth of either the *Micrococcus* or *Candida albicans*.

Having determined the susceptibility of these two microbes to both neomycin and sulfathalidine, four honey-guides were exposed to these antibiotics, as follows: Bird No. 1 received a mixture of 0.125 mg. per ml. each of neomycin and sulfathalidine daily in its drinking water. Birds No. 2 and 3 received 0.25 mg. of either neomycin or sulfathalidine, and Bird No. 4 received no antibiotic at all. In addition, all the birds were fed, as usual, domestic beecomb, free of bee larvae, ad libitum. Droppings were collected from these birds for isolation studies in order to check the efficacy of these two compounds to "sterilize" the intestine. The results are shown in Table 10.

TABLE 9

*Susceptibility of the* Micrococcus *and* Candida albicans *to antibiotics*

| ORGANISM | ANTIBIOTIC | SENSITIVITY |
|---|---|---|
| *Micrococcus* | Neomycin | Sensitive at 1 μg/ml. |
| | Sulfathaladine | Sensitive at 5 mg. per cent |
| *Candida albicans* | Neomycin | Insensitive |
| | Sulfathaladine | Sensitive at 5 mg. per cent |

TABLE 10

*Survival of the honey-guide with and without antibiotic treatment*

| BIRD NO. | ANTIBIOTIC | SURVIVAL (days) | ISOLATED ORGANISMS FROM THE DROPPINGS |
|---|---|---|---|
| 1 | Neomycin & sulfathaladine | 16 | *Micrococcus* absent; few *Candida* |
| 2 | Neomycin | 39 | *Candida* present; few *Micrococcus* |
| 3 | Sulfathaladine | 8 | Neither present |
| 4 | Control | 18 | Both present |

In the presence of a 1:1 mixture of the two substances the *Micrococcus* was absent from the droppings, few *Candida* were present, and the bird survived for 16 days. The birds receiving sulfathalidine, to which both organisms are sensitive, survived for the shortest period of time, 8 days, and neither organism was present in the droppings. In the case of the individual given neomycin, to which *Candida* is completely insensitive and the *Micrococcus* sensitive, the bird survived longest. The control bird, as was to be expected, survived its usual period of time, 18 days, and both organisms were present in its droppings. Generally speaking, these results indicate that both organisms are required for the survival of the birds.

## DISCUSSION

The accumulated evidence reveals certain basic facts about wax metabolism in the honey-guides, although the small number of birds that were available to us at any one time makes it desirable to continue the study with additional examples further to establish the mechanism of wax degradation by the honey-guides.

There is no longer any doubt that the lesser honey-guide can and will maintain itself on a diet of beeswax for a considerable period of time. Exactly what it is that the wax supplies is still uncertain. As was previously known from the

habits of the birds in a wild state, wax by itself is not a complete diet, especially since the beeswax does not contain a sufficient amount of nitrogen for the healthful continuance of the birds. It appears that the wax supplies, at best, the carbon, and that the honey-guides use their nitrogen reserves to be able to survive for as long as several weeks. It is not suggested that beeswax is even a necessary supplement to the wild birds' insect diet, but it must contain something the birds want to eat, or they would hardly consume it to the extent they do. The evidence does not wholly rule out the possibility that beeswax may contain an essential growth factor, and not merely supply the necessary carbon. However, this possibility is greatly reduced by two lines of evidence. First, we have the fact that young honey-guides, which are reared by adults of other species that do not eat wax themselves or feed it to their young, and which do not quit the nest until full grown in size, attain their definitive bulk without the benefit of any wax-derived substances. Second, we have found that pure myricyl palmitate will also function to some extent in replacing beecomb as a carbon source. It is tempting to speculate whether, if a proper nitrogen source could be found, a honey-guide would maintain itself for its entire life-span on a waxy carbon source. Such experiments are actually planned, by addition of amino acids, vitamins, etc., to the drinking water of birds on a beecomb diet.

That the beeswax, or its chief component, myricyl palmitate, is actually metabolized has been ascertained in several ways. Both gravimetric determinations and the progressive changes in the determined saponification values leave no doubt that the birds have actually metabolized the lipid material they have ingested.

The central problem in the studies herein reported has been the mechanism by which the bird is enabled to metabolize beeswax to the point of extracting nourishment from it. The bulk of the evidence we have been able to obtain suggests that this breakdown is due to the microflora of the bird's intestinal tract. The fact that two organisms, a thus far unnamed coccus belonging to the genus *Micrococcus*, and a strain of the yeast, *Candida albicans*, have been found to be invariably present in the droppings of the birds, the high lipolytic activity of the microörganisms, and the presence of one of them in samples of wild African beecomb, all individually and collectively implicate them strongly as the causative agents. Of particular interest here are the antibiotic experiments. When one treats the birds with antibiotics in order to sterilize their intestinal tracts, they survive on a wax diet for a shorter period of time than the control birds do. These experiments, coupled with our inability to demonstrate significant lipolytic activity of avian tissues, leave little doubt that the two microbes are indeed responsible for the ability of the honey-guides to survive for an appreciable period of time on a diet of beeswax or beecomb. It should be stressed again, however, that additional experiments with a greater number of birds will have to be performed in order to elucidate further these various interesting observations. The relative scarcity of the birds in their native habitat, the few people familiar with them who can attempt to supply them, and the difficulties in trapping and transporting them in good condition make this desired checking of results a matter of time and opportunity, but we hope to be able to accomplish this.

As demonstrated by extensive field studies (Friedmann, 1955), the highly peculiar "guiding" behavior of some of the honey-guides is now known to be a form of excitement reaction of the bird when meeting with a potential foraging symbiont, i.e., with a creature, often a human being, that the bird associates with the act of opening bees' nests. Underlying this behavior, which for centuries has been a great stumbling block to naturalists attempting to explain it, is the cerophagous or wax-eating tendency of the bird. It was not enough to "explain" the basis for the habit by noting that the bird ate wax; it was necessary to demonstrate that the tendency to consume wax was really an important part of the dietary picture. Of this there can no longer be any doubt.

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# NEW BIOLOGICAL BOOKS

*The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will occasionally appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that* THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to H. B. Glass, Associate Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

## SORTS AND CONDITIONS OF DEVELOPMENT

BY JANE OPPENHEIMER
*Bryn Mawr College*

A Review of VORLESUNGEN ÜBER ENTWICKLUNGSPHYSIOLOGIE.

*By Alfred Kühn. Springer-Verlag, Berlin, Göttingen, and Heidelberg.* DM. 43.60. ix + 506 pp.; ill. 1955.

"Der Eintritt bestimmter Entwicklungsvorgänge," writes Kühn, "ist jeweits die Reaktion auf bestimmte Entwicklungsbedingungen. . . . Das Wesen der determinierenden und determinierten Funktionszustände in Innern der Zellen ist uns unzugänglich, wir können sie nur aus regelmässigen Erfolgen bestimmter Bedingungen erschliessen." The principal effort of his *Vorlesungen* thus is to define, describe, and analyze some of the conditions under which specific developmental phenomena occur.

The book consists of 30 lectures altogether. The first 5, after introducing in general terms the problems which confront the developmental physiologist, deal with the nature of the chromosomes, of the mitotic and meiotic processes, and of cell division. The next 3 take up reproductive processes, first in selected unicellular forms, then in some organisms categorized by Kühn as noncellular (*Saprolegnia, Bryopsis, Acetabularia*), and subsequently in such apparently simple multicellular forms as the colonial phytomonads and the slime molds. Moving on to the supposedly more conventional multicellular organisms, the 3 succeeding lectures discuss fertilization, polarity, and cleavage. Two are then devoted to the development of echinoderms and 6 to that of amphibians; the next 2 to mosaic development in the ascidians and in forms with spiral cleavage, the 3 following to the development of insects, and 2 to the development of plants. The 4 final chapters return to more general considerations; in turn, material arrangements (an inadequate translation of the somewhat awkward German "Materialordnung") as related to developmental processes; the genotype as a condition of development; lethal factors; and, finally, the nature of the operations of the gene. While the contents of the book are being described, special compliments must be paid to the appropriateness, clarity, and beauty of the pictorial illustrations. One wonders how one can have taught embryology in the past without owning a lantern slide of each.

A simple enumeration of the topics covered by each of the lectures, while necessary to demonstrate the enormously wide range of the data presented, is, however, totally inadequate to characterize the contents of the book. Kühn himself provides rather full subtitles for each lecture, e.g., that for the chapter on Materialordnung bei Differenzierungsvorgängen is "Formbildungsleistungen in Gewebekulturen als Modelle funktioneller Strukturbildung in Stützgeweben. Biokristalliner Charakter des Echinodermskelets; funktionelle Strukturen, nichtfunktionelle Korrelationen." But even the outline embodied in his full table of contents indicates only vaguely the design of the full texture of the volume, and, in fact, furnishes a far less vivid image of the author's lucidity of insight into fundamental problems than emerges from inspection of the Table of Contents of his own *Grundriss der allgemeinen Zoologie*.

Yet whoever will take the trouble to read the lectures thoughtfully (and, indeed, such is their character, both in content and style, that it is hardly possible to read them otherwise) will quickly learn that in them Kühn has approached, as nearly as has been done by any contemporary writer, a consideration of the fundamental principles of development, and the limitations to a closer approximation are not, as will be discussed below, necessarily of his own making. He himself has emphasized in his foreword that it is inevitable that

the material covered in lectures be highly selected. The data which he has included have been chosen for their aptness to illustrate whatever particular principles they happen to exemplify, and the facts described are subjugated not to some idle and dreamy speculation, but to just that degree of completely unselfconscious theoretical analysis which culminates in the production of workable working hypotheses for future investigation. The author makes no attempt to formulate a general unifying theory of development, a circumstance which lends strength to his presentation rather than otherwise, since probably the most fundamental of all generalizing principles for the study of development is that a main feature of what distinguishes one organism from another is the fact that for each the inherent developmental pattern is unique in itself and in its innermost essence unlike that of every other.

But for all that, he has succeeded in producing a coherent descriptive analysis, if not a theory, of development, and since he too is well-nigh unique in his way, it may prove rewarding to inquire into some of the factors that may be partially responsible for his proficiency.

In the first place, he is unique in having at his command an exhaustive knowledge of the development of a wide variety of organisms that is unequalled in scope by that of any other investigator who currently concerns himself with developmental problems. Facts, however, can sometimes be located more conveniently in encyclopedias than in minds, and the sheer quantity of information which Kühn communicates does not alone present an accurate measure for his superiority. To his familiarity with morphogenetic phenomena he adds an equally profound understanding not only of the heredity of organisms, but also of their characters of life and habit, and he can therefore evaluate their developmental traits in terms of their broadest possible biological significance. Kühn, furthermore, knows how to compose as well as to expose, and he has a rather exceptional gift of organizing his material with judgment, simplicity, and grace, and further (and this is, perhaps, the most exceptional of all his abilities) with economy. There is scarcely a word in his whole text which is dispensable, and in the short space of less than 500 pages he has encompassed a wealth of detail which, it is probably safe to say, no one else now writing could cover in 2 or 3 times as many.

One is tempted, without wishing to detract one iota from Kühn's very evident talents as a writer, to attribute his success in succinct exposition at least in part to the nature of the language which he uses. Certainly the German language lends itself extraordinarily well to just such precision and concision of expression as Kühn indulges in, and to just such a systematic ordering and organization of facts as that in which he excels even when presenting the complicated and heterogeneous mass of details which constitute the present corpus of morphogenetic knowledge.

The peculiar advantages of the German tongue for the expression of systematic—or unsystematic—biological thought are themselves phenomena that may be worthy of brief attention. The modern German language is favorable for the presentation of facts and ideas in orderly arrangement because it is neat. It attains its compactness in part by piling noun on noun to make a noun that is more than the sum of its nouns (admittedly to its own stylistic detriment and to that of the languages which imitate this habit). But its suitability to biology reaches beyond the mere rules and practices of grammatical construction. The very character of the words themselves seems to render them especially applicable for the expression of fundamental morphogenetic concepts of an abstract nature. It might be maintained, for instance, that developmental physiologists working in America or England suffer from the fact that the ideas embodied in such phrases as "wahrnehmbare Mannigfaltigkeit" or "kombinative Einheitsleistung," or in particular in the word "Auslösung," are not to be translated into the English language as directly as, for instance, the word that is in German "Induktion." The concept of "Auslösung" as developed by Driesch in his *Analytische Theorie der organischen Entwicklung*, which I happen to consider the most influential publication produced during the formative years of experimental embryology, was far broader and more comprehensive than the concept of induction which is subsidiary to it. It is a real possibility that the success of the German embryologists, from Herbst through Spemann to Holtfreter, in giving such meaningful reality to the secondary principle of induction rested in part on their awareness of the implications of the broader concept. And it may even be that elsewhere the concept of induction has subsequently become inflated to primary importance simply because there exists an easy word for it which is nearly identical in many languages. Whether or not these inferences are valid, it has by now become eminently clear that the whole impasse into which the concentration on induction has drawn embryologists can be circumvented only when the other implications inherent in the concept of Auslösung have been taken into full cognizance.

But the problems of language can be penetrated to a deeper level than those relating to convenient usages of words. It can be argued that the structure of languages reflects as well as affects the functions of the minds that construct and evolve and use them, and it has long been a foible of this reviewer to speculate that the peculiar suitability of the German language to embryology is partly related to a rather special affinity that exists between embryology and German minds—at least in so far as these latter can be considered as historical entities. German minds have had the breadth, have had the depth, have had the power, have had the system to deduce the most significant of the laws of

morphogenesis that the embryo has so far permitted to be revealed.

But minds, like embryos, develop too in environments which can provide conditions favorable or unfavorable for the realization of their potencies to the fullest degree. There have been intellectual environments which have been conducive to the development of just such knowledge and just such treatments of knowledge, as Kühn's book exemplifies to an ultimate degree—and one of the best was the German university system in which Kühn was bred during one of its most fruitful periods. The German universities instilled in the minds developed in them, however, something more than the abilities to know and to systematize and to organize. These can lead to pedanticism, too, as they probably have, say, in the philological sciences. Something more is needed to account for the particular affinity of the 19th Century German mind, and its 20th Century progeny, for embryology. The great German embryologists, from Caspar Friedrich Wolff through Pander and von Baer to Roux and Herbst and Driesch and Boveri and Spemann and Holtfreter, have had the imagination to induce themselves to function en rapport with the embryo in a manner for which it is hard to find a counterpart in any other land and for any other material in the history of modern biology.

Can this, too, be accounted for in any measure on an historical basis? It is not to explain, but to describe, their situation to say that they were in a sense in love with the embryo, and thus able to fathom some of its secrets by processes of understanding that transcend the usual minimum procedures of scientific thinking. And why? Because they could see the embryo whole, and it is this that relates their infatuation with the embryo to their moment in history. Within the fields of science, they were the flower of the whole romantic movement which could enable them to comprehend the wholeness of the embryo as part of the wholeness of nature (remember von Baer's dream for the embryology of the future: "die bildenden Kräfte des thierischen Körpers auf die allgemeinen Kräfte oder Lebensrichtungen des Weltganzen zurückzuführen") and the romantic nature philosophy, emotional as it was at heart, could allow them to indulge their affections for the embryo in a manner that colder and more calculating scientists would rarely permit themselves. No matter how remote from its center some of them may have felt themselves to stand, they were nonetheless imbued with its spirit.

If one may go so far as to inquire as to why these characteristics seem special to embryology, in contrast to other divisions of biology, the answer may again come from history; and this time, specifically from the status of the development of history itself, which was also coming to full bloom in the minds of the German philosophers during the same period. Owsei Temkin, in an illuminating essay published about five years ago (*Bull. Hist. Med.*, 24: 227–246. 1950) has taken measure of the extent to which the ideas of ontogenetic development linked with philosophies of nature and history in German romantic thought in the years around 1800; the magnitude of the debt which the elaborators of embryological concepts owe to Herder and the later German philosophers of history has not been adequately weighed by recent embryologists, but surely it is very considerable indeed.

From this point of view, it is a kind of historical inevitability that has dictated that such a book as Kühn's could roll only from the lips or pen of a German author. The discussion may seem to have run far afield, but when the reviewer was handed the book to review she was asked (not by the book review editor, but by a not-so-innocent bystander who worries over the inadequacies of American textbooks) to try to account for Kühn's mastery over his subject. But if his excellence may be partly explained on an historical basis, which is what the previous discourse attempts, history is not enough. That distorted as well as masterful minds have emanated from the Germany of the great universities has been only too evident to us all, and no evaluation of the historical setting in which his mind was developed can subtract from his own abilities; in the final analysis it is to Kühn himself, more than to the past that produced him, that we are obligated for his having made the vast conglomeration of developmental physiological data more intelligible to us than any writer on the same subjects since Schleip.

But if, over and above straight knowledge, intuitive insight into embryonic wholeness has been at the core of the German affinity for the embryo, what has been the special contribution of Kühn in this connection? It was stated at the beginning of this review that he has presented a coherent analysis of development. What is the cohesive element in his thinking?

A frequent German definition of development is "das Entstehen wahrnehmbarer Mannigfaltigkeit"—the coming into existence of perceptible manifoldness. Nineteenth century investigators before Roux concerned themselves largely with das Wahrnehmbare, or what is perceptible. This is the practice that Pander initiated, the results of which von Baer generalized, with such momentous effect. The early experimentalists took up what they considered an analysis of the processes involved in Entstehen, Roux in terms of a kind of inflexible and rigid causality which is considered suspect by more modern philosophy of science, Driesch finally in relation to metaphysical concepts which seduced him away from the embryo into realms where many scientists have preferred not to follow him. No general concepts of embryology of the rank of von Baer's and Roux's and Driesch's have been formulated subsequently which allow the incorporation of the presently available information into a single framework, and all of the countless bewildering variations inherent in developmental phenomena have driven embryologists into a form of despair which cannot be dissipated by

any such simple expedient as entitling books "The Principles of Development." It was said above that the general principles of development are not apparent from Kühn's outline of this book as represented by his Table of Contents. The truth is, that they have not yet become completely evident to any recent embryologists from considerations of the presently known embryological data.

Nor are they likely to do so as the result of a mere act of will in the absence of what only can be called inspiration of the sort that fired the great German embryologists of the last century and of the early years of this one. What Kühn accomplishes in his lectures is to focus attention on a method of applying our efforts profitably while we bide our time, namely, concentration on the conditions of development. He reminds us of what we were told by Claude Bernard, who, though not in any sense a developmental physiologist, saw in development the guiding principle to an understanding of life itself, and who issued the same dictate as Kühn when he defined physiology as "the science whose object it is to study the phenomena of living beings and to determine the material conditions in which they appear."

If all of the countless hundreds of communications we read in the many journals specify the conditions under which specific developmental phenomena occur, their deficiency is that they do little more. For Kühn, concentration on conditions of development becomes the cohesive element by virtue of his feelings for general biology. The conditions operative, in this light, become the clue to the Wahrnehmbare, to the Mannigfaltigkeit, and to their Entstehen. His own statement of his problem as quoted in the beginning of this review seems almost deceptively simple, but surely it is a mark of a great mind to make simple what may have been forgotten as obvious. In so doing, Kühn has taken full benefit of the past and at the same time looks always to the future, and the developmental physiologist, as he awaits his new moment, will do well to have this book of Kühn's on his desk, and its analysis in his mind, as his eyes fill themselves with the living developing organism.

# REVIEWS AND BRIEF NOTICES


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## GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

REASON AND NATURE. *An Essay on the Meaning of Scientific Method.*

*By Morris R. Cohen. The Free Press, Glencoe.* $6.00. xxiv + 470 pp. 1953.

This stimulating and fascinating volume by one of America's greatest philosophers is a long overdue reprinting of the first edition, published in 1931. As set forth in the foreword, the author found so many points where revision appeared necessary that he declined, for many years, to authorize a reprinting of the original volume. Even in this edition not all of the hoped for revisions were fully worked out.

Any part of this essay would, in all probability, be very differently assessed by physicists, biologists, psychologists, philosophers, or other "specialists." Although it discusses problems fundamental in the approach to and interpretation of each of these fields, this is not Professor Cohen's primary purpose. He wishes to use considerations of reason, scientific method, and the physical, natural, and social sciences to pursue a much broader intellectual area. His major concern is the hostility between nature and reason, or "what are popularly called the heart and the mind"—in other words, the often mentioned but little considered conflict between an appeal to nature in the form of sentimental irrationalism and an appeal to reason which suppresses "nature in the interest of conventional supernaturalism." In working through the bases, causes, and effects of this conflict, it is essential to understand the methods by which scientific results are achieved, and in accordance with which such results are altered, reinterpreted, and continually reintegrated into existent fact and concept. "In developed natural science, reason and nature are happily united."

Part of the author's need to carry out this great contemplative and analytic study arose from a dissatisfaction with what he refers to as the arid state of present-day technical philosophy, the snare of special-

ized technical competency in which many philosophers have been caught. Very wisely, indeed, Professor Cohen states that, "A good deal of the unsubstantiality of later scholasticism was no doubt due to the fact that having elaborated a very subtle technical vocabulary, men felt themselves to be distinguished scholars by the mere mastery of such a vocabulary. The change from Latin to the vernacular revealed this emptiness and compelled a greater attention to substantial content. But this gain is now largely frittered away in philosophy and in the related fields of psychology and sociology, in which exercises in technical vocabulary frequently hide the paucity of substantial insight." In some intelligible way, the critical scientific method must be applied to the great classical views of the world.

His disappointment with the philosophers is equaled by his recognition of the inability of most scientists to carry scientific method into their views of other phases of life and the world. Nor is he impressed with the greater part of the religious and philosophic lessons they have drawn from science. Consequently, his thesis is addressed in equal portion to the philosopher, the scientist, and, in general, the thoughtful reader.

In a masterful analysis and exposition almost all phases of experience and science are clarified, and the clarification serves to bring reason and nature together in a rational interpretation of the world we live in. Certainly this is a volume which no student or investigator into the sciences of life should fail to study.

R. G. GRENELL

SCIENCE AND MAN'S HOPE.

*By James Street Fulton. Bookman Associates, New York, for The Rice Institute.* $3.25. 179 pp. 1954.

*Science and Man's Hope* is an attempt by a professional philosopher to clarify the relationships of ethics and science in the 20th Century. Fulton, considering himself a qualified philosophical rationalist, starts out from the premise that "while science itself cannot *define* man's hope, it can and does partly *reveal* it," whence he proceeds to the belief that "the special value of science lies not in what it makes of the world but in what it makes of the knower, or, rather, in what he makes of himself in achieving veracity in cognition." His respect for life is such that he sees hope in heightened aliveness, which can be won "only by the intellectual quickening of sensibility and the thoughtful strengthening of moral ties, so that the intenser life essentially expresses fidelity to nature in knowledge and fidelity to man in loyal action. Intensification of the distinctively human traits in existence," he continues, "requires an opening out of a man's vital center to its real ties in the universe."

"This is the promise of science," he writes, "that man may through it achieve openness, awareness, and be fulfilled." While a good bit of his argument rings familiar, his special emphasis on openness as a key concept is developed with some originality. "Values, properly speaking," he writes, "have reality only in a life that is lived in full awareness of what we are doing." He puts great store in what he calls becoming aware inwardly and knowing one's own substance: "reason is the response of inwardness to its hope and promise." "Value," he says later, "cannot be taught or learned in a verbal formula, but only illuminated by reflection and suggestive wisdom. Thus it is inward; it is the living being in its liveness, the living process sensitive to its needs and responsive to its promise; it is the dynamic integrity of the agent which appears to the outward observer as the organism-as-a-whole. . . . Value is the essence of life. . . . The passion for openness is the effort of life to realize possible goodness. . . . Reason . . . . is the effort of life to become responsive and responsible. . . . Life is worth living, life in all forms. . . . The activity of living involves enjoyment of life's inward essence, and the experience of value is a forward pressure. . . . How else could it be, if life's refined intensity is loving compassion for creative effort, and if its fruition is openness?"

The argument is sound from a philosophical point of view, and raises problems of great moment. It has a special appeal for the biologist, since the author views life as a condition of great pre-eminence in the universe, as may be inferred from the quotations above.

These extracts, however, give only a sketchy delineation of the complete pattern of the author's thought, and the whole text must be read through with careful attention if its contribution is to be fully appreciated. While the book is well-written, it will be followed readily only by those who are accustomed to steeping themselves in the contributions of professional philosophers, which in their intense concentration on complicated sequences of abstractions make extremely difficult fare for the ordinary and less rarefied mortal to absorb. Since the scientists who write on the philosophy of science are usually so patently naive, it is a pity that the philosophers fail to address the scientists in terms that they can more readily grasp—that is, in a style that they can read without translation. Is there not, for instance, another way to say what the author has written in the second of the quoted sentences above, "achieving veracity in cognition"? But this is a quarrel with the habits of a discipline and not with the present author, whose book well deserves to be read with thoughtfulness by all thinking biologists.

JANE OPPENHEIMER

IDEOLOGIE UND FORSCHUNG IN DER SOWJETISCHEN NATURWISSENSCHAFT. *Schriftenreihe Osteuropa Nr. 1. By Arnold Buchholz. Deutsche Verlags-Anstalt Stuttgart.* DM 2.90 (paper). 126 + ii pp. 1953.

A condensed but very complete and up-to-date outline

of the effects of communistic philosophy on scientific research and research standards in the U.S.S.R. The account begins with a short history of Russian science, which is followed by a brief description of the impact of dialectical materialism on mathematics, physics, and chemistry. Here we are shown how the physical scientists have protected their sciences from the Party Line by means of simple verbalistic evasions. Astronomy and cosmology follow in that order and lead to a chapter on the origin of life where the "correct" views are, naturally, those of A. I. Oparin.

More space is devoted to the biological sciences than to the physical sciences, for it is in biology that Marx and Engels stated their views precisely and in detail. Here, of course, evasion is much more difficult. For biological advances to be acceptable they must be (1) compatible with the doctrines of Marx and Engels, and (2) made by individuals who are personally acceptable. Thus cellular pathology is "in error" and is inadmissible because its founder, Rudolph Virchow, was a "reactionary." On the other hand, the theories of Olga Leperchinskaia, which hold that living cells are developed out of non-cellular and lifeless protein, are now official.

The rise of Lysenko to power is next described and the technique he used to destroy genetics. Now, however, Lysenko is having his own troubles which seem to have come from his efforts to correct Darwin's "errors" about the origin of species. The work ends with a brief survey of the other biological sciences and particular emphasis on the conformity forced upon the physiologists, who have to adhere closely to the work of Pavlov.

Of especial value is a bibliography of nearly 400 titles. The whole work furnishes an excellent starting-point to anyone who wishes to learn just what has happened to Soviet science.

CONWAY ZIRKLE

SCHOOL HEALTH EDUCATION. *A Textbook for Teachers, Nurses, and other Professional Personnel. Revised Edition.*

*By Delbert Oberteuffer. Harper & Brothers, New York.* $4.50. x + 454 pp. 1954.

Like the first edition, this text is designed for use by college and university students preparing for service in teaching, nursing, and medicine. The book is written in three parts. Part One, The Foundations of School Health Education, presents the health problems which confront the school population and the community, and which therefore must be dealt with in health education, and suggests how this may be done effectively. Part Two, The Curriculum and Teaching, discusses the planning of instruction—various approaches, methods, organization of courses, integration of material, resources, and, finally, the evaluation of instruction. Part Three, Administration and Activities, deals with health activities or services, such as programs for the handicapped and nutrition and mental health programs, appraisal activities, and policies for improving community relationships. There are extensive references and an index. Appended are a personal history form and a copy of the Policies of the Worthington (Ohio) School and Community Health Council.

The book appears to fulfill very well the purpose for which it was intended. It is thorough, but clear and concise, and demonstrates considerable enthusiasm for the integration of school health experience with the needs of the pupils and of the community—needs with which the readers must deal in their professional activities.

H. D. VERA

FOUNDATIONS OF BIOLOGY. *Foundations of the Unity of Science, Vols. I and II, International Encyclopedia of United Science. Vol. I, No. 9.*

*By Felix Mainz. University of Chicago Press, Chicago.* $2.00. (paper). iv + 86 pp. 1955.

## BIOLOGY: HISTORY AND BIOGRAPHY

GREAT EXPERIMENTS IN BIOLOGY.

*Edited by Mordecai L. Gabriel and Seymour Fogel. Prentice-Hall, Englewood Cliffs, N. J.* $3.95. xvi + 317 pp.; ill. 1955.

The scientist differs from the non-scientist principally by the fact that problems are his daily fare, that he seeks them rather than deliberately avoids them. The motives for this difference in mental behavior probably arise from the elation which the scientist feels and needs and which comes from the sense of discovery. This feeling cannot be shared with the non-scientist unless he too knows of the existence of the problem, of the compelling reasons why a solution is needed, and the meaning of an answer in terms of some larger body of information. Since science today is so much a part of our everyday existence, and since so much of the taxpayer's dollar is being expended for the solution of scientific problems, it is important that the taxpayer should appreciate the role of the scientist in today's society, even if he does not fully understand it. The daily newspapers convey this information in a sporadic and fragmentary way, but all too frequently the overdramatization of the scientist and his discoveries has backfired to the extent of fostering a laical distrust of the scientist as a social being. A judicious presentation of scientific works can dispel this feeling to a certain extent (the articles in the *Scientific American* are good examples), but probably the most efficient method is for the lay public to become acquainted with scientific

endeavors at first hand by reading the original literature. The present volume is an attempt to assemble such material in a convenient form, and the idea goes back to the "Great Books" courses and the General Education courses as developed at Harvard University under President Conant.

Some 60 or more papers have been selected by Gabriel and Fogel for inclusion in this book. The span of time which is covered goes back to the observations of Robert Hooke on the cells of cork, and extends to the modern period with the studies of Beadle and Tatum, Dobzhansky, van Niel, Spemann, and others. Each paper, which is presented in full or by substantial extracts from it, is placed in proper perspective by means of a brief discussion by the editors and with the aid of a chronological chart which follows the development of a particular segment of biology. One can always argue, as the editors point out, that the selection of papers is somewhat arbitrary, and that pertinent articles have been omitted, but the selection on the whole is a fair one which will give the reader not only a general survey of a particular field, but also a sense of its historical development as that was affected by the particular discoveries embodied in the papers. The areas covered include the following: the cell theory; general physiology, further subdivided into enzymes, hormones, vitamins, and metabolism; microbiology; plant physiology, divided into auxins and photosynthesis; embryology, subdivided into the germ cell theory and embryonic differentiation; genetics; and evolution. Since all of the papers are in English, some foreign works are here made available in translation for the first time.

It is interesting to observe, even among these few selected papers, the loss of the personal element in the more modern papers that was so evident among the earlier ones. The modern research article has had the personality of its author largely squeezed from it by the form in which most journals insist that their papers be presented. The scientific value of a discovery, of course, loses any personal connotations once it is absorbed into a larger body of information, but the depersonalized form of modern scientific reporting has converted the Darwins and Pasteurs of today into human blanks which assume recognizable proportions only when the author is the recipient of a Nobel prize or is called before a Congressional investigating committee. It is to be hoped that the present volume will restore a bit of the human element to the science of biology.

C. P. SWANSON

APES, ANGELS, AND VICTORIANS. *The Story of Darwin, Huxley, and Evolution.* *By William Irvine. McGraw-Hill Book Company, New York, London, and Toronto.* $5.00. xiv + 399 pp. + 8 pl. 1955.

For at least five reasons this is a difficult book to review. First, the narration sails along with such ease and generates such interest that the reader becomes absorbed to the point of thinking only the author's thoughts. Second, the book deals with an idea so broad in its impact that to be soundly critical of the book one needs a solid background in economic and political history, in literature, in philosophy, in religion, as well as in science. Third, the men, Huxley and Darwin, are so exceptional in their accomplishments that almost any reviewer will have strong doubts about his ability to understand many facets of their lives and works. Fourth, the writings of Darwin and Huxley are so extensive that to have studied all of Darwin alone will have occupied the spare hours of any teacher-scientist for years. Fifth, the author has so interestingly entwined the biographies and works of Darwin and Huxley with each other, with the lives and thoughts of their wives and relatives, and with the lives and thoughts of Hooker, Lyell, Owen, Wallace, Carlyle, Butler, etc., that no pattern is evident for ready summation.

A short chapter on the speeches of Owen, Wilberforce, and Huxley on evolution at the Oxford meetings of the British Association, 1860, introduces the subject, sets the rather dramatic tone of the book, and presents one episode to illustrate the position of Huxley as the champion of Darwin's ideas. Three chapters deal with Huxley's early life, the voyage of the Rattlesnake, and his early achievements as a scientist. We secure here the picture of a boy and young man whose abilities as a student seem hardly limited even by time. Nine chapters, with the exception of an interlude, outline Darwin's life and work. Darwin's boyhood and youth, up to the voyage of Beagle, contrast strongly with Huxley's. No great capacities as a student were evident; no strong drive, except an active but scattered curiosity, was present. The voyage of exploration was a much stronger determining factor in the life of Darwin than in the life of Huxley. It was on the voyage that the development occurred, so Darwin could say in his autobiography: "The above various special studies were, however, of no importance compared to the habit of energetic industry and of concentrated attention to whatever I was engaged in, which I then acquired. Everything about which I thought or read was made to bear directly on what I had seen or was likely to see; and this habit of mind continued during the five years of the voyage. I feel sure that it was this training which has enabled me to do whatever I have done in science."

Biographical details surrounding the development of the fruits of these habits of mind (23 volumes with many revisions, a long list of papers, and five volumes of letters) are presented by Irvine intermixed with the

main theme—the clash of evolution with ideas inside and outside of science. Huxley weaves through the fabric of these chapters as a friend and as a proponent of evolution.

While Darwin devoted most of his life to the development of evolution as a scientific idea, Huxley carried the idea far afield. His great contribution to the furtherance of evolution was the insistence that the theory be accepted or rejected on scientific grounds. This was indeed a great service to Darwin and to science, for even most scientists were unable to isolate and consider evolution purely on its scientific merit.

Although Huxley insisted on a scientific evaluation of evolution by others, he was active in extending its applicability to limits that were outside the range of operation of biological science. This extension by Huxley, and even more so by Spencer, forms an interesting contrast with the work of Fritz Müller, which is solidly within the confines of biology (*Facts and Arguments for Darwin*. John Murray, London. 1869. Trans. by W. S. Dallas). Müller brought the theory of evolution to bear in his examination of the morphology, physiology, and developmental history of several crustacea with such success that he became a strong supporter of evolution.

Although Müller is not discussed by Irvine, Müller's method and attitude can well be examined as models to be followed in the examination of any new idea and can be strongly contrasted with the looser methods of others described by Irvine. A few sentences from the preface and first 13 pages of Müller's book present his position.

"It is only by accumulation of new and valuable material that the controversy [over Darwin's theory] will gradually be brought into a state fit for final decision, and this appears to be for the present of more importance than a repeated analysis of what is already before us. . . .

"A false supposition, when the consequences proceeding from it are followed further and further, will sooner or later lead to absurdities and palpable contradictions. During the period of tormenting doubt—and this was by no means a short one—when the pointer of the scales oscillated before me in perfect uncertainty between the *pro* and the *con*, and when any fact leading to a quick decision would have been most welcome to me, I took no small pains to detect some such contradictions among the inferences as to the class of Crustacea furnished by the Darwinian theory. But I found none, either then or subsequently. Those which I thought I had found were dispelled on closer consideration, or actually became converted into supports for Darwin's theory.

"Nor, so far as I am aware, have any of the *necessary* consequences of Darwin's hypotheses been proved by any one else, to stand in clear and irreconcilable contradiction. And yet, as the most profound students of the animal kingdom are amongst Darwin's opponents, it would seem that it ought to have been an easy matter for them to crush him long since beneath a mass of absurd and contradictory inferences, if any such were to be drawn from his theory. To this want of demonstrated contradictions I think we may ascribe just the same importance in Darwin's favor, that his opponents have attributed to the absence of demonstrated intermediate forms between species of the various strata of the earth. . . .

"If the absence of contradictions among the inferences deduced from them for a narrow and consequently easily surveyed department must prepossess us in favor of Darwin's views, it must be welcomed as a positive triumph of his theory if far-reaching conclusions founded upon it should *subsequently* be confirmed by facts, the existence of which science, in its previous state, by no means allowed us to suspect."

Müller described in the remainder of the book how facts about crustaceans fell neatly into the new patterns supplied by the idea of evolution and how evolution permitted the prediction of new facts which were subsequently discovered. That Darwin himself operated this way can be seen throughout his works. An example is cited by Irvine from Darwin's cirripede work. His "species theory" led to the discovery of a new species in which each female "invariably has two husbands" in little pockets. Irvine also notes that the orchid work is an application of the theory of natural selection to this group of plants.

Irvine's comments about Darwin as a speculator are somewhat conflicting (see pp. 73, 74, 77, 79, 98, and 104), but in being so they represent quite well Darwin's changing views on speculation ("theorizing"). Probably Darwin's best statement on this subject, but not quoted by Irvine, is in a letter to Woodd (*More Letters*, vol. II): "I can have no doubt that speculative men, with a curb on, make far the best observers."

Near the end of Chapter 7, after discussing Darwin's theory, Irvine states: "Darwin's chief error consists in the Malthusianism which makes Victorian economics so gloomy. He assigns too large and positive a role to death and elimination. . . ." In relation to this kind of interpretation one needs to keep in mind the section headed The Term, Struggle for Existence, Used in a Large Sense (*Origin of Species*, ch. 3). In this section are these, too seldom quoted, statements: "I should premise that I use this term in a large and metaphorical sense including dependence of one being on another, and including (which is more important) not only the life of the individual, but success in leaving progeny. Two canine animals, in a time of dearth, may be truly said to struggle with each other which shall get food and live. But a plant on the edge of a desert is said to struggle for life against the drought, though more

properly it should be said to be dependent on the moisture." (We might be less gloomy if we could see that in an important sense man is less like the canines and more like the desert plant.)

Although Darwin kept evolution fairly close to biological facts, Huxley pushed through evolution into ethics, theology, philosophy, education, and applied biology. The prodigious labors expended in exploring and reporting his contacts with all these areas are covered quickly in the remaining 6 chapters of this book. The pace is too fast for the ordinary mortal. So much is brought to mind in such a short space of time that one becomes tired. Yet this impression that Irvine develops brings us closer to the driving force of Huxley's power and energy than would a more extended discussion of the usual type used in reporting the work of scientists.

A questioning mind is bound to be confused by many discussions such as those reported in this book in which a scientific idea is being pushed into and beyond the limits of applicability of the idea. Yet within this confusion lie some of the great opportunities for fundamental advances. When the limits of applicability are explored within the realm of science, after the pattern of Müller, one takes great satisfaction in the argument and in the outcome. When the limits are explored within science by those outside of science, one finds largely the confusion of a Wilberforce or a Butler. (They had not taken time to do their barnacles.) When the limits are explored outside of science by Spencer, Huxley, and others, one finds a vastly diminished fruitfulness. The criteria and methods are no longer those of Müller. We become vastly confused yet increasingly fascinated. Since one can never be sure where real progress lies, either inside or outside of science, man will continue to explore ideas in all directions, and books like Irvine's will encourage this activity by summarizing previous work and by stimulating others to attempt difficult labors so that there may develop today new Huxleys and new Darwins.

RALPH W. LEWIS

SPIDER, EGG, AND MICROCOSM. *Three Men and Three Worlds of Science.*

*By Eugene Kinkead; introduction by E. B. White. Alfred A. Knopf, New York.* $4.00. x + 244 pp. 1955.

This little book, part biography and part natural science, is a brisk piece of writing which touches deftly on many things small and large, human and divine, and as far sub-human as it is possible to go and still talk about life. The fast pace suggests Lytton Strachey in his familiar *Portraits in Miniature*, and the author's enormous and insatiable appetite for curious facts and arresting erudition is reminiscent of H. L. Mencken. But here the similarity ends, for Eugene Kinkead lacks the cat-like touches of ironic malice found in Strachey or the learned vulgarities so well contrived to deflate a man which were part of the stock-in-trade of Mencken.

By contrast, Kinkead looks up to his subjects. And well he might, for the three men of whom he has chosen to write, in a sense displaced persons, have brought honor to the institutions in which they have lived and worked, and have conferred truly great gifts on their adopted country.

Alexander Petrunkevitch, at Yale for over forty years, is the first of the three. "Pete," as he is known affectionately to hundreds of students, is a giant of a man, physically, humanly, and in his knowledge of spiders. Ask anyone except Petrunkevitch himself and you will learn that he knows more about spiders and their life and structure than any other man who has ever lived. Kinkead has succeeded in conveying both a sense of the compelling fascination of spiders as objects of scientific investigation, grotesque with their eight eyes, their powerful and poisonous jaws, and their mechanically precise behavior, as eerie as creatures from another solar system, and also a sense of Petrunkevitch as a person. As an old student of his, I can certify that this account has the ring of authenticity.

Alexis Romanoff (of the non-royal Romanoffs) has devoted his life at Cornell so exclusively and with such intensity to the study of the eggs of hens and other birds that not only has he become the towering authority in this field, but his wife and all else in his life have come to appear as trivial irrelevancies far out on the periphery of his egg-centered life. Sometimes, in fact, it is difficult to tell just when Kinkead stops writing about the wonders of eggs as seen by Romanoff and begins writing about Romanoff. The eggs are Romanoff. Yet even in this strange man Kinkead perceives the universal humanity. Romanoff, on the threshold of old age with a host of challenging problems about eggs yet unsolved, walked across the Cornell campus one balmy afternoon. A student was lounging against a tree and idly gazing out across Lake Cayuga. After Romanoff had passed, he half turned and muttered: "Wonderful loafer, sell me some time!"

Roman Vishniac, the third of these Russian-born Americans, is an amazing virtuoso of the camera. The camera has been to him what the spider has been to Petrunkevitch and the egg to Romanoff. Vishniac at the age of seven began photographing animals in his bedroom, later made his reputation by photographing the life of the underprivileged Jews of eastern Europe, and eventually came to this country, where inter alia he has taken prize-winning pictures of Einstein in his study at Princeton and parameciums in their mud puddles. One gathers that this man has seen a lot. One may detect here and there throughout this portion

of the book a slight note of amusement at Vishniac's excitement over one-celled animals, but this must be because Kinkead has not had a favorable opportunity to observe them for himself.

Very rarely indeed does a scientific error slip in. Penicillin, the antibiotic, is used where the author means *Penicillium*, the mold that produces it. Actually a great deal is known about the role of cytochrome. It is only its function in certain specific cases that is uncertain.

Beyond the superficial unity of an early life in old Russia, polylingual ability, and marked mechanical ingenuity, there lies a spiritual unity in the lives of the three men here depicted. As E. B. White makes clear in his introduction, each succumbed to an "enchantment, various, luminous, divine." It is a tribute to our land that they came here to be free to seek the Truth.

GAIRDNER B. MOMENT

## THE YOUNG NATURALIST

MEN, MICROSCOPES, AND LIVING THINGS.

*By Katherine B. Shippen; illustrated by Anthony Ravielli. The Viking Press, New York.* $3.00. 192 pp.; ill. 1955.

Katherine Shippen is an established writer on things scientific, and her audience is the younger generation. Her range is wide although her particular competence lies in the social field. In this volume she enters the area of biology to trace from Aristotle to T. H. Morgan the history of the science as it has unfolded through the ages. She does this by concentrating on particular scientists whose findings or generalizations form the major milestones from the past to the present. Here one finds mention of such names as Aristotle and Pliny, Vesalius, Harvey, Bacon, Malpighi, Linnaeus, Cuvier, Lamarck, Darwin, von Baer, Schleiden and Schwann, Schultze, Mendel, DeVries, and Morgan—truly a galaxy of brilliant stars. Miss Shippen describes their work and its significance simply, accurately, and effectively, with only an occasional tendency toward superlativeness, over-generalization, or undiscriminating veneration. The scientist-to-be will find this an enjoyable and informative treatment of the history of biological thought and action.

C. P. SWANSON

FOOD FOR PEOPLE.

*By Sarah R. Riedman; with a foreword by John Boyd Orr; illustrated by Helen Ludwig. Abelard-Schuman, New York.* $2.50. 192 pp.; ill. 1954.

This is an elementary book on nutrition which might be of interest to youngsters in grade school or adults with little training in the sciences. Sarah Riedman presents her information in a story-book style and tells how the facts about nutrition were learned, how much food you need, the vitamin story, and deals with other subjects related to nutrition.

R. VAN REEN

MALAYAN ANIMAL LIFE.

*By M. W. F. Tweedie and J. L. Harrison. Longmans, Green & Company, London, New York, and Toronto.* $2.50. x + 237 pp. + 1 pl.; text ill. 1954.

To so much as enumerate the vast Malayan fauna would require more than the 237 pages which the publishers have allowed to be devoted to the subject of this little book; yet within its pages are surveyed vertebrates and invertebrates, both terrestrial and aquatic, from salt and fresh water. With half of the book devoted to vertebrates, it goes without saying that in all groups only the more familiar forms are even mentioned, and concerning them only the briefest comments have been made. This brevity is to some extent compensated for by numerous pen-and-ink sketches, some of which are quite excellent. The book seems to be written primarily for the younger generation in order to stimulate greater interest in Malayan natural history. For this purpose it seems to be admirably suited. One should add that the text is in a very readable style, and many of the comments on habits, etc., could only come from one long familiar with the animal life of this zoologically rich region.

BRYAN P. GLASS

## ECOLOGY AND NATURAL HISTORY

UNDER THE SEA WIND. *A Naturalist's Picture of Ocean Life.*

*By Rachel L. Carson. The New American Library, New York; a Mentor Book.* 35 cents (paper). 157 pp.; ill. 1955.

THE EDGE OF THE SEA.

*By Rachel Carson; with illustrations by Bob Hines. Houghton Mifflin Company, Boston.* $3.50. xii + 276 pp.; ill. 1955.

Since the original publication of *Under the Sea Wind* in 1941, Rachel Carson has become something of a literary phenomenon, turning the subject of the sea to respectable reading matter for the clientele of the *New Yorker* and *Readers' Digest* sets and inspiring a fashion in literature about the sea, its ways, and creatures. In her most recent book she has returned to the subject of her first, writing with a more matured and

improved style. Whereas *Under the Sea Wind* was about the lives of birds and fishes of coastal waters, somewhat anthropomorphic (see *Q.R.B.*, 17:178. 1942), *The Edge of the Sea* is about the 3 types of shore along the Atlantic Coast, the rocky shore of New England, the sandy reaches of the mid-coast, and the coral coast of Florida, and the plants and animals (invertebrates especially) characteristic of these three environmental types. The environments are well described, that of the beach and its sands being especially well done. The book is rich in detail, often with bits of original observation, and without a trace of the personalization which upset some reviewers of her first book. There are, of course, the usual philosophical observations about the endless mystery of the sea, etc., that seem to occur in every such book, but they are very well put and have a lulling, comforting effect upon the reader. Yet we wonder if this book, for all the considerable literary skill that has gone into it, will be as successful as *The Sea Around Us*. Because of the inevitable amount of detail, it is not a book that can be read easily at a single sitting, and readers who cannot interrupt their reading by going down to the sea to look for themselves may lay it aside after a while. Those who are already interested in seashore life will, of course, read it to see what Miss Carson has to say, and how she says it.

Both books have brief appendices which provide details about various plants and animals, although some of the mistakes in that for *Under the Sea Wind* are still uncorrected. *The Edge of the Sea* is provided with an index which lists both common and scientific names. The utility of the latter is questionable, for there is often no clue in the text to the name in the index, and therefore only the professional zoologist who knows the names already can use it. Errors in the book are few, but we discover that a large part of the subject matter indexed under *Acmaea testudinalis* concerns California coast limpets of several species. Further, the author does not seem to realize that more than one species is concerned, which results in a somewhat confused discussion of homing in limpets. The attractive illustrations for the first edition of *Under the Sea Wind* have been omitted; those for *The Edge of the Sea* are excellently done, but are without scale and serve primarily as decoration. Many of them have no legend and are identified only by a name in the index which must be known by the specialist. This sort of thing is probably the publisher's fault, although it makes an attractive, reasonably uncluttered page. The people for whom the book is really intended, however, will probably not be disturbed by this arrangement. Since some of them will undoubtedly want to go deeper into the subject, a brief bibliography should have been provided.

JOEL W. HEDGPETH

THE WINDWARD ROAD. *Adventures of a Naturalist on Remote Caribbean Shores.*

*By Archie Carr. Alfred A. Knopf, New York.* $4.50. xvi + 258 + viii pp. + 12 pl.; text ill. 1956.

Except for the beginning of the account, which deals with sea-turtle adventures on the Florida Keys 18 years ago, the setting for this book is provided by the sandy beaches of Grand Cayman, off Cuba, of Tortuguero, Parismina, and Puerto Limón, Costa Rica, of Bocas del Toro, Panamá, and several parts of Trinidad. "Adventure," to Archie Carr, is "just a state of mind, and a very pleasant one, and no harm to anybody, and a great asset if you use it right." His adventures, as told, arose from a sponsored study of populations and habits of sea turtles, primarily green turtles, but also the loggerhead, ridley, hawksbill, and trunkback.

The Riddle of the Ridley is an entertaining enigma, since no one knows where this irascible turtle breeds in Atlantic or Caribbean Waters. Fishermen and turtle-hunters in these parts believe the animal to be a sterile cross between loggerhead and green turtle. But closely similar ridleys in the Pacific reproduce in a normal way.

While turtles are always in the background and often in the fore, Carr's account covers many other entertaining bits of natural history: the two-toed sloths in the Indian laurel trees of Puerto Limón's Parque Vargas; the eyeshines of many animals, including a misplaced prawn and a sea-beach jaguar; the voicing of frogs, particularly of the "paradox frog" *Pseudis*; the hatching of tree iguanas.

Throughout there is a nice balance between sympathetic understanding of the Latin American way of life and humorous appreciation of his own predicaments. Vicariously the reader joins the author in his field studies, even when he listens to a frog chorus, standing "like a shitepoke roost in the thin dark—a Full Professor in the prime of life—with my navel in the pond and five children back home going through their shoes; hearing the rare song and stowing it away, wondering. . . ."

Tom Barbour, to whom the book is dedicated, would have revelled in its pages. It will bring nostalgic pleasure to any naturalist who has wandered in Central America or the Antilles, and introduce others to these regions in the best informal way. Among the bits of colloquial Spanish idiom with which the pages are sparsely sprinkled we missed one, which can answer whether we enjoyed the rambling account: *Como no!*

LORUS J. & MARGERY MILNE

GULF OF MEXICO, ITS ORIGIN, WATERS, AND MARINE LIFE. *Fish. Bull. 89, Vol. 55.*

*Coordinated by Paul S. Galtsoff; prepared by American scientists under the sponsorship of the Fish and Wild-*

*life Service, U. S. Department of the Interior. Fish and Wildlife Service, U. S. Department of the Interior, Washington; [U. S. Govt. Printing Office].* $3.25 (paper). xiv + 604 pp.; ill. 1954.

The purpose of this book, as announced, is "to summarize in a convenient form the present knowledge about the Gulf of Mexico. Such a summary is needed in connection with a large number of new investigations which are now being conducted in the Gulf. . . ." It is essentially a compilation of information, comprising 71 articles by 55 contributors, arranged in 20 chapters. The contributions show a large variance; some are thorough and scholarly, others superficial and generalized. Conclusions and interpretations are presented by certain authors for their particular contributions, but there is no general summary or integration of the entire material or even of related topics, and no attempt was made to correlate extensively the physical and biological data. There is not even a general treatment of the zoogeography of the Gulf, though the contributor of the greatest number of articles, Joel W. Hedgpeth, has elsewhere done a fine job along this line. Some emphasis has been accorded the biology of commercially important animals, such as the oyster, but there is no adequate treatment of the fisheries, and even the fishes themselves are discussed sketchily. There is hardly a mention of the bearing of the Gulf and its marine life on aboriginal and modern man, and very little on man's effects on the Gulf, save for the last, and one of the most thorough, articles, dealing with water pollution.

In view of the shameful lack of attention to marine invertebrates in general and the lack of adequate provision for publishing even what little work is done on these animals, perhaps the greatest value of the volume lies in the more or less thorough treatment of the invertebrates. Among the more impressive articles on animal groups are those on Protozoa, by Victor Sprague; on Trematoda, by Harold W. Manter; and on the holothurians, by Elisabeth Deichmann. The chapters on birds, by George H. Lowery, Jr., and on mammals, by Gordon Gunter, are outstanding. The botanical sketches, on algae by Wm. Randolph Taylor and on flowering plants by Robert F. Thorne, are samples of what many of the other articles should have been like. The nonbiological articles treat the exploration of the Gulf, the physiography and geology, the meteorology, the tides and sea-level, the physical oceanography, light penetration, the distribution of chemical constituents, and the recovery of minerals from sea water—all by competent authorities.

CARL L. HUBBS

THE OCEAN FLOOR.

*By Hans Pettersson. Yale University Press, New Haven; Geoffrey Cumberlege, Oxford University Press, London.* $3.00. xvi + 181 pp.; ill. 1954.

This little book is the 33rd in the Silliman Lectures series. It is concerned primarily with the chemistry and bottom deposits of the deep sea, as investigated by the Swedish Albatross expedition in 1947–48. Chapters of special interest to biologists are those on the deep sea deposits and life of the deep sea. Both of these, however, are the more tentative parts of a book which is for the most part a preliminary account of work still under way. Since Hans Pettersson is almost as fascinating in print as he is in person, it is unfortunate that such a small book (in the purely physical sense) should cost so much.

JOEL W. HEDGPETH

STRANGE CREATURES OF THE SEA. *Strange Stories from Nature Series.*

*By A. Hyatt Verrill; illustrated by the author. L. C. Page & Company, Boston.* $3.75. xxvi + 236 pp. + 1 pl.; text ill. 1955.

This is the last of several books on sea life by A. Hyatt Verrill, who died in November, 1954 in his 83rd year. It consists of chapters on different categories of plants and animals, under such headings as Lobsters and Their Cousins, Dollars and Doughnuts of the Sea, etc., illustrated by simple line drawings and an unfortunate painting (reproduced as a colored frontispiece). Like his other books, it is a curious mixture of standard information, often garbled by faulty recollection (apparently the author had not kept up with the literature since his student days) and apparently outrageous fabrications, tossed together in a friendly, facile style to appeal to "younger readers." This book is not much different from an earlier version, *Wonder Creatures of the Sea* (D. Appleton-Century Co., 1940; reviewed *Q.R.B.*, 15: 485. 1940), with the same chapter organization, illustrations, and often the same sentences. Among the things that have been added in this version is a piece about the pycnogonid that advances from a hidden lair and sucks out the stomach contents of an anemone through its mouth while the anemone passively submits to its commensal, and then "goes stalking off on tiptoe to its den." Since the author is no longer able to defend himself, one should perhaps say "De mortibus nil nisi bonum" and assume that this sort of thing is either a first-hand observation that no one else has been fortunate enough to make, or an honestly misunderstood observation of something quite different, but we have reason to suspect otherwise. A fascinating book could be written about the long career of A. Hyatt Verrill, much more fascinating, perhaps, than anything he has ever written, although it might be hard for a biographer to stay within the bounds of legal propriety and yet approach the honest fiction by Verrill that gave many of us such boyish pleasure in the old days of Hugo Gernsback's thick, pulpy *Amazing Stories*.

JOEL W. HEDGPETH

ADVENTURING WITH BEEBE. *Selections from the writings of.*

*By William Beebe. Duell, Sloan & Pearce, New York; Little, Brown & Company, Boston and Toronto.* $4.50. xii + 283 pp. + 8 pl. 1955.

There is no need to discuss the writings of William Beebe. He has been on the scene as an accomplished naturalist-writer for longer than many of us can remember, and his popularity and the quality of his writing seem not to dim with the passing years. The present volume is not an original book, but rather a collection of some of the better chapters from earlier sources. Twenty-one chapters cover a span of 40 years of exploration and writing, and fall into three general categories which cover Beebe's work in the Bermudas, the Pacific, and the jungle. They are derived from seven of his published works: *Nonsuch: Land of Water, Half Mile Down, Zaca Ventura, Book of Bays, Jungle Peace, Edge of the Jungle,* and *High Jungle.* One can readily quibble with the selections, but if you enjoy Beebe you will find this a commendable and diversified collection of essays.

C. P. SWANSON

THE GIANT CACTUS FOREST AND ITS WORLD. *A Brief Biology of the Giant Cactus Forest of Our American Southwest.*

*By Paul Griswold Howes. Duell, Sloan and Pearce, New York; Little, Brown and Company, Boston, and Toronto.* $7.50. xxx + 258 pp. + 53 pl.; text ill. 1954.

If you enjoy natural history, you probably will like this book. If, in addition to having an interest in natural history, you live or have visited in the Southwest, you certainly will enjoy it. Howes subtitles his book A Brief Biology of the Giant Cactus Forest of Our American Southwest. I would call it a modern-day equivalent of *The Natural History of Selborne,* transposed to the giant cactus belt of southwestern Arizona.

A large share of the creatures—insects, amphibians, reptiles, birds, and mammals—and plants—cacti, trees, shrubs, and flowers—is described, and is well illustrated by the numerous good photographs. With the text figures and photographs, and the annotated listing of animals in the appendix, a native or even tourist visitor could identify many of the most conspicuous individuals seen in the cactus forest. It would be a shame, however, to stop with mere identification. Howes' narrative does more than describe; it presents the associations, lives, and hard times of the desert inhabitants. He imparts real personality and individuality to his plant and animal characters by his sympathetic, but always careful and sound, observation. An astounding amount of ecological observation is incorporated in the interesting text.

ALAN D. CONGER

PRÉCIS D'ÉCOLOGIE ANIMALE.

*By F. S. Bodenheimer; translated by J. Théodoridès. Payot, Paris.* 1,200 fr. (paper). 315 pp.; ill. 1955.

As a survey of a scientific field, Bodenheimer's book covers a lot of ecology, both old and new. Its three parts deal, respectively, with the animal in its habitat, with biotic coactions, and with the distribution of life. More than half of the text is devoted to the first of these parts, though overlapping of subject matter of the different parts occurs.

The French-reading student to whom this book is an introduction to ecology should gain a good idea of the fundamental requirements and complexities of living things. For the mature ecologist, the review of familiar literature may be leavened by discussions and examples from sources outside of his accustomed reading. In the latter connection, I think especially of the author's own most interesting work in the Middle East—not only on invertebrates but also on such phenomena as "cyclic" fluctuations of voles.

The book, I should say, is rather uneven in its treatment, and at times while reading it I had the thought that something may have been inadvertently left out. (There are many editorial or printing irregularities, authors are often cited without corresponding references in the bibliography, etc.) My over-all impression is that Bodenheimer, while by no means wholly neglecting inherent resiliences or intercompensations in reproductive and mortality rates of animals, did not take them into as full account as he might have. Nevertheless, the scholarship behind the book is impressive, and I am glad to have had the opportunity to read it, for its broader aspects as well as for those in which I have special interests.

PAUL L. ERRINGTON

NATURAL HISTORY OF THE SALAMANDERS OF THE PLETHODONTID GENUS *ENSATINA. Univ. Calif. Pub. Zoöl., Vol. 54, No. 2.*

*By Robert C. Stebbins. University of California Press, Berkeley and Los Angeles.* $1.25 (paper). Pp. 47–124; ill. 1954.

This contribution is a continuation of Stebbins' detailed studies of western North American salamanders. In 1949, he presented a careful and complete account of the systematics and distribution of salamanders of the genus *Ensatina.* The present paper, in the same critical manner, describes original investigations on the life history of members of this genus. Because of Stebbins'

efforts, *Ensatina* is probably the best-known genus of salamanders at the present time.

Observations are recorded for the usual life history topics: longevity, reproduction, feeding habits, ecology, seasonal activity, etc. Stebbins had marked over 500 individuals by toe-clipping and has found that there is considerable localization of movement. Over a period of years, most specimens ranged no further than 65 feet from the place of original capture. (Similar results have recently been obtained by Richard Highton in a study of another plethodontid, *Plethodon glutinosus*.) The paper also includes the description of the results of some laboratory studies designed to determine the tolerance limits of factors that might be limiting under natural conditions.

ARNOLD B. GROBMAN

RED FOXES AND A DECLINING PREY POPULATION. *Monograph Ser., No. 1.*

*By Thomas G. Scott and Willard D. Klimstra. Southern Illinois University, Carbondale.* $2.00 (paper). iv + 123 pp.; ill. 1955.

This publication integrates the findings of two investigators, each primarily concerned with a different phase of an ecological problem yet working in close cooperation. The problem itself was of the sort that now and then furnishes the natural equivalent of a good experiment in field ecology, and the alertness of the investigators in taking advantage of their opportunities paid off in the form of one of the most enlightening case histories in the literature on predator-prey relationships. The big variable in the southern Iowa situation kept under regular observation, 1946–48, by Scott and Klimstra was the drastic decline of the principal wild prey species exploited by the local fox population; and the resulting phenomena were further appraised on the basis of the senior author's previous long-term investigations of red fox behavior and food habits on two other Iowa areas. The stringencies described by Scott and Klimstra appear to be quite special, at least for the north-central United States. Also described is a notable instance of the foxes responding to the vulnerability of a poorly managed flock of domestic chickens.

PAUL L. ERRINGTON

PHYSICAL OCEANOGRAPHY OF THE IRISH SEA. *Minist. Agric., Fish., Food, Fish. Invest., Series II, Vol. XVIII, No. 8.*

*By K. F. Bowden. Her Majesty's Stationery Office, London.* 7s. 6d. (paper). 67 pp.; ill. 1955.

COMPARATIVE LIMNOLOGY OF EIGHT COLORADO MOUNTAIN LAKES. *Univ. Colo. Stud. Biol., No. 2.*

*By Robert W. Pennak. University of Colorado Press, Boulder.* $1.50 (paper). iv + 75 pp.; ill. 1955.

## EVOLUTION

DIE EVOLUTION DER ORGANISMEN. *Ergebnisse und Probleme der Abstammungslehre. Second Edition. Parts 1–4.*

*Edited by Gerhard Heberer; contributors, H. Dingler, E. von Eickstedt, H. Friedrich-Freksa, W. Gieseler, G. Heberer, W. Herre, Ch. v. Krogh, W. Lehmann, K. Lorenz, H. Lüers, W. Ludwig, K. Mägdefrau, O. Reche, A. Remane, B. Rensch, L. Rüger, F. Schwanitz, H. Ulrich, J. Weigelt, and W. Zimmermann. Gustav Fischer Verlag, Stuttgart.* Lief. 1, DM 14.30 (paper); Lief. 2, DM 21.00 (paper); Lief. 3, DM 23.90 (paper); Lief. 4, DM 11.70 (paper). xvi + 856 pp.; ill. 1954; 1955.

The first edition of this compendious work appeared during the war (1943) and did not become widely known outside of Germany. Publication of a second edition has permitted extensive revision and should find wider circulation. The plan, as before, is a series of essays, each by a competent German authority. Scope and general approach are best indicated by a summary of the table of contents:

Part One, Basis and Methods: Dingler on philosophical foundations; Zimmermann on phylogenetic methodology; Rensch on phylogenetic changes in ontogeny; Lorenz on psychology and phylogeny.

Part Two, History of Organisms: Rüger on absolute geological chronology; Weigelt on paleontology as phylogenetic documentation; Friedrich-Freksa on viruses and the origin of life; Mägdefrau on the history of plants; Remane on the history of animals.

Part Three (in two Lieferungen), Causation: Schwanitz on genetics and evolution in plants; Lüers and Ulrich on genetics and evolution in animals; Ludwig on selection; Schwanitz on the origin of cultivated plants; Herre on domestication of animals.

Part Four (announced but not yet received), Phylogeny of the Hominidae: Heberer on additive typogenesis; Krogh on man's place among the primates; Gieseler on fossil hominids; Reche and Lehmann on human racial genetics; Eickstedt on the phylogeny of mentality.

The fourteen essays so far published average over 60 pages in length, and several of them might well have been issued as separate books. In effect, this work is a whole library of technical review-monographs on evolutionary subjects. There is, however, little repetition and virtually no essential contradiction among the contributions of so many authors and from such diverse specialties. With expectable differences of emphasis and detail, all the authors support an essentially mutation-selection theoretical view of the evolutionary process. This is strong (and to a considerable degree independent) support for the general theory of evolution now nearly universal among English and American students of that subject. It is even a little surprising, because the strongest dissent from mutation-selection theory

comes from students in continental Europe. Aside from the fact that the theory seems still to be banned in Communist countries, its adherents are probably in a minority in France and there is some outspoken criticism of it in Germany—by Schindewolf, to mention only one of the most illustrious examples. In this work, proposed alternatives to mutation-selection are mentioned only briefly by a few of the authors, and only to be discarded.

It may, indeed, be felt that some of the authors of this great work, starting with the first two, are all too rigidly and literally of the mutation-selection school. Consideration of mutation as *the* motive force of evolution tends to obscure the importance of genetic interaction and recombination. A negative Darwinian concept of selection as the elimination of the unfit is less general and less constructive than the genetical concept of selection as differential reproduction. The synthetic theory as developed, say, by Huxley or by Dobzhansky is more subtle and more complex, and to that extent more competent to deal with the subtle, complex phenomena of evolution.

That is not to say that the authors of this work limit the processes of evolution to mutation and selection or invariably give selection such a restricted and negative role. The article on selection itself (51 pages by Ludwig) treats selection as one of five factors that can upset the Hardy-Weinberg (or, as here, Weinberg-Hardy!) equilibrium, thus producing evolutionary change: mutation, selection, annidation, drift, and isolation. The interplay of all five is emphasized, and the conclusion is reached that no one alone could result in progressive evolution, with the theoretically possible but not actualized exception of mutation.

It is inherent in the editorial plan of separate, even though coordinated, essays that the quality varies and that gaps remain. There is inadequate treatment of the fossil record. Weigelt's contribution, published posthumously and not revised by him, is a somewhat disorganized sequence of shorter discussions and examples, each excellent in itself but all together not providing a balanced discussion of the topic, "Paleontology as the study of phylogenetic documentation." Remane's long (82 pp.) treatment of the history of animals devotes most space to a highly speculative and rather sterile consideration of the origin of phyla and other high categories, mostly on the evidence of their living representatives. Throughout the work, isolating mechanisms are several times mentioned, but hardly more than mentioned. The methodological section does not do justice to the growing importance of population methods in evolutionary genetics and systematics, and this oversight is not wholly compensated by the presence of some discussion of populations in later sections. There is no review of the history of evolutionary theory, or (except for somewhat casual mention) of current alternative and supplementary theories.

It is far easier and less demanding of space to note omissions or inadequacies than to give a full, positive appraisal. Indeed, fourteen long studies cannot be individually reviewed under one heading. Here the too easy recourse of harassed reviewers is literally true: any serious student of the subject must read this work and have it at hand on his shelves. It is extraordinarily rich in ideas and information. Of special importance to American readers are the extensive bibliographies, including over 800 titles on plant genetics and evolution alone, and shorter but still usually large lists for other topics. It is an additional advantage that the literature in German, much of it poorly known in this country, is especially well covered.

G. G. Simpson

Status of Invertebrate Paleontology, 1953. *Bull. Mus. Comp. Zool. Harvard Coll., Vol. 112, No. 3. Edited by Bernhard Kummel. Museum of Comparative Zoology at Harvard College, Cambridge.* $2.50 (paper). Pp. 91–318; ill. 1954.

The papers united in this stimulating volume were presented orally in a symposium arranged at the annual meeting of the Paleontological Society in Toronto, Canada, November 1953. The purpose of that symposium was to summarize the present knowledge and current problems concerning taxonomy, evolution, and ecology of the more important invertebrate phyla. Since these essays by specialists, nearly all collaborators of the *Treatise on Invertebrate Paleontology* under the editorship of R. C. Moore, are themselves of reviewing character, it seems inappropriate to try here a further review. To give an idea of the rich content it may suffice to cite the titles of the individual papers.

N. D. Newell introduces the series by a contribution Toward a More Ample Invertebrate Paleontology. He predicts and requests that developments in invertebrate paleontology in the near future will be characterized by an increasing emphasis on the more biological aspects of it. The following papers are concerned with a survey of several phyla and classes of invertebrates. The fossil Protozoa are reviewed by H. E. Thalmann; the Coelenterata by J. W. Wells; the Pelmatozoa by R. C. Moore; the Eleutherozoa by J. W. Durham; the Pelecypoda by N. D. Newell; the Gastropoda by J. B. Knight, R. L. Batten, and E. L. Yochelson; the Cephalopoda by B. Kummel; the Trilobita by H. B. Whittington; and the Graptolithina by O. M. B. Bulman. These papers give excellent accounts of the present state of knowledge of the groups and are illustrated by many figures relating to the morphological organization, the evolutionary patterns, the number of fossil genera and species, the geological distribution, etc. O. H. Schindewolf reports on Development, Evolution, and Terminology of Ammonoid Suture Line. The question of Macroevolution and the Problem of Missing Links is discussed by A. Petrunkevitch, an

advocate of the macroevolutionary concept. R. C. Moore investigates the Evolution of Late Paleozoic Invertebrates in Response to Major Oscillations of Shallow Seas. The conclusion is reached that some fusulinid genera in Lower Permian cyclic deposits of the midcontinent region seem to reflect influences of shallow-sea oscillations. The last chapter, by H. A. Lowenstam, is devoted to the Systematic, Paleoecologic and Evolutionary Aspects of Skeletal Building Materials, a new and very promising field of paleobiologic research.

O. H. SCHINDEWOLF

SILICIFIED MIDDLE ORDOVICIAN TRILOBITES. *Geol. Soc. Amer. Mem. 59.*

*By H. B. Whittington and W. R. Evitt, II. The Geological Society of America, New York.* $3.00. xii + 137 pp. + 33 pl.; text ill. 1954.

This outstanding memoir is based on a material of unrivalled preservation and completeness, offering all opportunities for an extremely detailed morphological investigation. The trilobites were obtained from limestones in the vicinity of Strasburg, Shenandoah County, Virginia. They are silicified in ideal perfection and can easily be etched out by a solution of hydrochloric acid. Thus freed from matrix, both the inner and outer surfaces of the exoskeleton may be studied to reveal many particulars previously unknown. The remains are undistorted and include different growth stages, so that the development of each species can be described.

The first part of the paper discusses Occurrence, Techniques, and Terminology. The second chapter is devoted to the General Morphology and Development of the Exoskeleton and contains a wealth of new information. In cheirurid trilobites (and probably also in others) the hypostome apparently was firmly braced against the remainder of the cephalon and could not be moved. The maculae probably were neither visual organs nor areas of muscle attachment. The articulation and enrollment of the thorax is described with many details. Canals through the exoskeleton with openings at the tips of spines and tubercles, and between the raised ornament, were probably occupied by hairs having a sensory function. Besides the protaspis of *Acanthoparypha*, the ontogenies of the described genera, and the mode of life are amply discussed.

The Systematic Descriptions given in part III include 16 species (15 new) distributed in couples among 8 genera (3 new) and 3 families, one family and one subfamily being new. The plates, partly stereographic and partly strongly enlarged unretouched photographs, are admirable.

O. H. SCHINDEWOLF

ORDOVICIAN CEPHALOPOD FAUNA OF BAFFIN ISLAND. *Geol. Soc. Amer. Mem. 62.*

*By A. K. Miller, Walter Youngquist, and Charles Collinson; containing a study of the Ordovician Trilobites from Silliman's Fossil Mount by Harry B. Whittington; and shorter supplements and notes by Preston E. Cloud, Jr., Charles E. Decker, Y. O. Fortier, A. Scott Warthin, Jr., and Alice E. Wilson. The Geological Society of America, New York.* $4.75. viii + 234 pp. + 63 pl.; text ill. 1954.

Earlier papers have given evidence of rich Ordovician faunas on Baffin Island, but the material forming the basis of these reports was mainly collected by laymen and was somewhat scanty. Now, some years ago, the senior author, accompanied by Youngquist, had an opportunity to visit Silliman's Fossil Mount at the head of Frobisher Bay in southeastern Baffin Island and to make large collections at this place, which is perhaps the richest of the known fossiliferous localities in the Arctic Lower Paleozoic. The assemblage includes a large variety of well-preserved receptaculids, corals, trilobites, ostracods, gastropods, and cephalopods, as well as a few graptolites, bryozoans, echinoderms, and members of other groups. This type of fauna is widespread in northern North America and Greenland; its age is determined as early Upper Ordovician.

All groups of the fauna are discussed and (with only the exception of the ostracods) amply illustrated on the splendid plates accompanying the paper. The cephalopods, which form the bulk of the material, are described monographically. They are respresented by 23 genera with at least 50 species, many of them new. The receptaculids and corals were determined only cursorily; the brachiopods have been identified by P. E. Cloud. The trilobites are extensively dealt with by H. B. Whittington, who recognized 18 species belonging within 15 genera. Two new genera of cheirurids (*Hapsiceraurus* and *Remipyga*), a new subgenus of *Bumastus* (*Bumastoides*), and a new genus of asaphids (*Anataphrus*) are proposed. Three fragmentary graptolites are briefly described by C. E. Decker. A small supplement by Y. O. Fortier on outliers west of Silliman's Fossil Mount, with a list of fossils contributed by A. E. Wilson, concludes the valuable paper, which marks important progress in the knowledge of the early Paleozoic faunas of the Arctic.

O. H. SCHINDEWOLF

EVOLUTION OF THE VERTEBRATES. *A History of the Backboned Animals Through Time.*

*By Edwin H. Colbert. John Wiley & Sons, New York; Chapman & Hall, London.* $8.95. xiii + 479 pp.; ill. 1955.

Edwin H. Colbert needs no introduction to either the

scientific world or the non-professional public. As Curator of Fossil Reptiles, American Museum of Natural History, and Professor of Paleontology, Columbia University, his professional studies and popular writings, especially on fossil mammals and reptiles, are well known and highly respected. His new book, written in characteristically clear and pleasing style, comprises a general survey of the history of backboned animals through geologic time.

Following an introductory summary of fundamental concepts (the nature of fossils, geologic time, the basic structure and temporal sequence of vertebrate animals, and brief elements of classification), the detailed fossil records of the fishes, amphibians, reptiles, birds, and mammals are, for the most part, treated individually. Within this general framework, however, Colbert has accomplished a novel breakdown of the subject matter into chapters. His methods of emphasizing morphologic differences, phyletic diversifications, and adaptations to particular environmental conditions are two. Firstly, the knowledge of one class of backboned animals may be highly departmentalized, as for example, the account of the fish-like vertebrates which is divided into four chapters that treat successively the primitive jawless lampreys and ostracoderms, the early armored fishes with the first movable jaws, the sharks and ray-finned fishes with advanced jaws, and the air-breathing dipnoan and lobe-finned fishes. Secondly, the review of distantly related groups may be combined into one chapter under a discussion of a common but analogous adaptation. Thus, the flying reptiles and birds and all of the varied marine reptiles of the Mesozoic are united with general considerations, respectively, of the "problems of flying" and the adaptations of terrestrial vertebrates to life in the oceans. Interspersed through the book, usually at the end of parts dealing with a particular class, are chapters of pertinent comment on the environments inhabited by these particular animals, the distribution in time and space of the sediments from which their fossil remains are found, and the successions of faunal associations. The result has been an effective presentation of the highlights of a very long and complex history. The overall effect of the book is enhanced by the new and refreshing pen and ink illustrations.

Certain apparent liberties taken in the composition of some of the phyletic diagrams throughout the book may well be subject to criticism by professional paleontologists. Good examples of these are to be seen in the chart (fig. 19, p. 60) entitled, The Evolution of Cartilaginous and Bony Fishes. The middle and upper Devonian palaeoniscoid *Cheirolepis* is shown on the main line of bony fish evolution. Although probably not in itself ancestral to any subsequent development, *Cheirolepis* is certainly representative of the chondrostean fishes, from which assemblage all later ray-finned fishes must have derived. Unfortunately the chondrosteans are not shown to diverge from the main evolutionary line until Triassic time. Again, *Redfieldia*, in the upper Triassic, is pictured as ancestral to the Holostei, whereas the latter group was fully developed in the late Permian. The principal difficulty in these examples is the loose conversion of an arbitrary and strictly horizontal classification into a supposedly vertical and phyletic one. Simplification in a book designed primarily for the general student and lay reader is undoubtedly legitimate, although the degree to which it may be carried will always be a subject of debate. Certainly the same omissions are not reflected in the text and, in any event, do not greatly detract from a work which will undoubtedly enjoy great success as another of the popularizations of technical subjects now so much in demand.

D. H. DUNKLE

THE GENUS *NICOTIANA*. *Origins, Relationships and Evolution of its Species in the Light of their Distribution, Morphology and Cytogenetics. Parts I–V: Distribution, Morphology, Cytology of Species, Cytology of $F_1$ Interspecific Hybrids, Phylesis. Part VI: Taxonomy. Chronica bot., Vol. 16, Nos. 1–6.*

*By Thomas Harper Goodspeed; Parts I–V by T. H. Goodspeed; Part VI by T. H. Goodspeed, H. M. Wheeler, and P. C. Hutchinson. The Chronica Botanica Company, Waltham; Stechert-Hafner, New York.* $12.50. xxii + 536 pp. + 8 pl.; text ill. 1954.

*Nicotiana* is a genus of some sixty species, and is related on the one hand to the genus *Petunia* and on the other to the genus *Cestrum*. All belong in the Solanaceae. In distribution, *Nicotiana* occurs largely in the western hemisphere, but with about one-quarter of the known species native to Australia and a few islands of the South Pacific. Taxonomically, the genus and its species are well defined, and practically all of the species have been collected and grown in the Botanic Gardens of the University of California. Hybridization between species can be carried out with reasonable ease, so that the stage was set for a most extensive investigation into the origin, relationships, and evolution within a distinctive group of species. For the past forty or more years this has been Professor Goodspeed's major interest, and the results have been assembled in the present volume. In approaching the problem, which is obviously an intricate and ramifying one, the techniques of plant geography, taxonomy, and cytogenetics have been used judiciously, and the result has been to make *Nicotiana* one of the most thoroughly studied of plant genera.

The book, in a sense, is comparable to that devoted to the genus *Crepis*. Since the studies on both genera

were done in the same institution, the similarities of approach to the evolutionary systems at work is not surprising, and undoubtedly both groups of workers drew knowledge and inspiration from each other. It is also clear that the evolutionary patterns in the two genera are basically similar even though differences are immediately obvious. *Nicotiana* appears to have been derived from a 6-chromosome ancestor even though existing species no longer possess so low a base number. The majority of species fall into the 12- and 24-chromosome groupings, with base numbers of 9 and 10 as well as 12 in the section Alatae, and an aneuploid series of 18 to 22 at the higher levels of polyploidy. The chromosomes are small and although satellites are present, the morphology of the individual members of the complement is not sufficiently varied to be of great diagnostic value in determining species relationships. There is no pronounced decrease in size of chromosomes among the more specialized sections of the genus as was found in *Crepis*, and indeed the opposite seems to be true, in that the members of the genus which are physiologically the most specialized possess the largest chromosomes. The primitive type of chromosome is presumed to be that type with a median centromere; a good deal of chromosomal asymmetry is encountered, but it appears to show no obvious relationship to the degree of taxonomic specialization. This again is contrary to the trends exhibited by various *Crepis* species.

On morphological as well as cytogenetic grounds, it has been concluded that present-day diversity in the genus has come about through the usual reshuffling of the hereditary material through mutations and aberrations, and with amphiploidy having played a dominant role. The 6-chromosome ancestors have disappeared, and it is uncertain whether the aneuploid base numbers between 6 and 12 have arisen by an increase from the original 6 or a decrease from a derived number of 12. *Nicotiana*, however, is a polyploid genus, and Professor Goodspeed believes that hybridization at both the lower and higher levels of amphiploidy, followed by segregation and isolation, has contributed to specific and varietal diversity. Apomixis has not entered the evolutionary picture as it has in *Crepis*, leaving the limits between species reasonably well defined under natural conditions.

In addition to the cytogenetic data which are presented in some detail, sections are also presented on the distribution, morphology, and taxonomy of the genus. These will be of interest to botanists in general, although it should be mentioned that the discussions on morphology are largely confined to floral characteristics. The volume itself is of course a monumental work representing the labors of a lifetime, but it will present little that is new to evolutionary thought. It is perhaps too harsh to say that *Nicotiana* seems to be a rather prosaic genus, exhibiting little in the way of evolutionary originality. It is, however, only by unravelling the inner workings of a genus of this sort that this can be determined, and it would be fair to say that *Nicotiana* has followed a path which is now known to be a well-travelled one by angiospermous genera. It has lost some of its potential plasticity for future change through elimination of its 6-chromosome ancestors. Its future in terms of higher levels of polyploidy, however, remains largly unexplored, although its propensity to thrive in man-disturbed areas suggests that the genus has not yet reached an evolutionary dead end.

C. P. SWANSON

THE CARBONIFEROUS FLORA OF PERU. *Bull. Brit. Mus. (nat. Hist.) Geol., Vol. 2, No. 5.*

*By Wilhelmus Josephus Jongmans. The British Museum (Natural History) London.* 15s. (paper). ii + pp. 191–223 + 10 pl. 1954.

THE SCHIZAEACEAE OF THE SOUTH OF ENGLAND IN EARLY TERTIARY TIMES. *Bull. Brit. Mus. (nat. Hist.), Geol., Vol. 2, No. 7.*

*By Marjorie E. J. Chandler. The British Museum (Natural History), London.* 15s. (paper). ii + pp. 291–314 + 7 pl.; text ill. 1955.

FAUNA OF THE VALE AND CHOZA: 10. *Trimerorhachis: Including a Revision of Pre-Vale Species. Fieldiana, Geol., Vol. 10, No. 21.*

*By Everett Claire Olson. Chicago Natural History Museum, Chicago.* 85 cents (paper). Pp. 225–274; ill. 1955.

FURTHER CONTRIBUTIONS TO THE SOLUTION OF THE PILTDOWN PROBLEM. *Bull. Brit. Mus. (nat. Hist.), Geol., Vol. 2, No. 6.*

*By J. S. Weiner, W. E. Le Gros Clark, K. P. Oakley, G. F. Claringbull & M. H. Hey, F. H. Edmunds, S. H. U. Bowie & C. F. Davidson, C. F. M. Fryd, A. D. Baynes-Cope, A. E. A. Werner & R. J. Plesters. The British Museum (Natural History), London.* £1. (paper). Pp. 225–287 + 5 pl.; text ill. 1955.

## GENETICS AND CYTOLOGY

GENETICS AND METABOLISM.

*By Robert P. Wagner and Herschel K. Mitchell. John Wiley & Sons, New York; Chapman & Hall, London.* $7.50. xii + 444 pp.; ill. 1955.

Analytical biologists, in the search for underlying mechanisms of living systems, are drawn more and more into biochemistry. This is true in morphology, physiology, and especially modern genetics. The fusion of genetics and biochemistry may not be complete yet, but the book *Genetics and Metabolism* is an important product of the union in its present state.

The book starts with general introductions to the gene concept, to cell structure and function, the nature of mutations, and the physiological consequences of

mutations. Chapters 5–8 present a dynamic concept of the present status of metabolism. This section does not attempt to be a substitute for a biochemistry textbook, but it is a powerful and sophisticated complement to the usual presentation of biochemical knowledge. What Wagner and Mitchell do attempt, and to a very large extent accomplish, is to give an idea of what goes into the structure of a dynamic state of metabolism. They start with single reactions, and with examples drawn from current research as well as basic considerations of enzyme kinetics illustrate the many ways in which the rate of a single step can be altered. From this they work up to the multiplicity of ways in which a single gene change can result in altered metabolic rates, and these in turn to the accumulation of an anomalous product or the deficiency of some substance normally present. They proceed then to present various complex areas of metabolism, as worked out with the aid of genetic blocks. The conclusion they come to is an extremely important one—that when a single gene is changed, it is a gross oversimplification to expect that only one step in all of metabolism will be altered. Of necessity, the whole pattern of metabolic rates has been altered, and this altered pattern of rates is what is inherited.

This section on metabolism is one of the most thoughtful and careful analyses I have ever seen, in its continuous attention to the many alternative explanations possible for any apparently simple phenomenon. It will be very rewarding reading for everyone who ever changes the composition of a living cell—whether by means of a gene mutation, a chemical or biochemical reagent, a physical condition, a surgical operation, or a parasitic organism.

All these considerations of metabolism are fully illustrated by examples from recent research (the references comprise 726 entries). The need to summarize a large number of rather complex experiments has produced a few difficulties in the text or tables. The subheadings of Table 25 are inadequate to differentiate between two different sets of experiments, as the text claims they will. Table 27 is a list of several *Neurospora* mutants and the $N^{15}$-labelled compounds fed to each. Unfortunately for the reader's understanding of the experiment, the relationship between each genetic block and the respective compound fed in the medium is not made clear. Occasionally the discussion is so condensed (p. 169) that it is unnecessarily difficult to follow the reasoning involved. These are minor flaws in a major work, however.

The next chapters (9–12) are concerned with the subject matter of advanced genetics: alleles and pseudoalleles, genic interactions, cytoplasmic inheritance, etc. The characteristic that distinguishes this part of the book is a willingness to stop after each genetic phenomenon and discuss probable or possible mechanisms for the phenomenon at the biochemical level.

*Genetics and Metabolism* is, to my mind, remarkable for a really profound appreciation of the dynamic state of living matter. An excellent example is in the section on cytoplasmic inheritance. The experiments in this area have been done primarily with single cytoplasmic components: chloroplasts of corn or *Euglena*; altered mitochondria in yeast or *Neurospora* strains; kappa in *Paramecium*. It has been the experience of this reviewer, and is probably not uncommon, to think of these particles as rather complicated but essentially discrete and unvarying little buttons floating around in the cytoplasm. Wagner and Mitchell go to some length, however, to point out (in at least two of the cases examined so far) that the particles (mitochondria) have been altered, not in one, but rather in a number of ways. In one case the enzymatic ability of the particle itself changes during development; in another instance the structure of the particle itself is threatened seriously by a greatly increased proteolytic activity, which in turn is held in check by a natural inhibitor inside the cell; in both cases the full evidence supports the view that many metabolic rates within the particles have been altered to produce an entirely new system, again always in motion but sufficiently stable to survive. Not only this, but when the particles have changed, it is possible to detect changes in the soluble enzymes of the cytoplasm at the same time; so that it becomes conceivable that the new dynamically stable state of the cytoplasm has either been the cause of a new pattern of metabolic rates in the particle, or results in the stabilization of the pattern. And finally, Wagner and Mitchell point out the likelihood that cytoplasmic inheritance may reside in an altered, sufficiently stable new dynamic state of the soluble parts of the cytoplasm, and may not be limited to definitive particles at all. The button analogy is unquestionably an oversimplification.

The book concludes with a chapter on the mechanism of development, and another on mechanisms in nutrition and disease. Once again, these subjects are reviewed at an advanced level and with a high degree of sophistication, after a presentation of sufficient background material for those who do not work directly in those fields.

*Genetics and Metabolism* is not a book that can be skimmed through, or that can be recommended for beginning students. It is one, however, that offers high rewards for careful study. It is to be hoped that it will be revised frequently enough to keep up with a rapidly expanding field of biology.

A. T. Jagendorf

The Biochemistry of Genetics.
*By J. B. S. Haldane. The Macmillan Company, New York.* $2.75. 144 pp.; ill. 1954.

In this extremely concise and condensed book Haldane undertakes to answer the questions: what do genes do,

and how do they do it? what are the genes in a biochemical sense? how do the genes reproduce, and what is involved when a gene mutates? After two introductory chapters which raise the foregoing questions and consider the nature of the unknown primary products of gene action, the author in successive chapters surveys the biochemical genetics of fungi; of yeasts, bacteria, and viruses; of the higher plants; and of the higher animals, especially man. These chapters attempt to put so much into so little space that intelligibility suffers. Only a reader already thoroughly conversant with the facts will be able to follow the evidence, and such readers will not need this type of summary. Less competent readers and all beginning students will be well advised to go instead to a fuller and better developed discussion, such as the general survey of the field in *Genetics and Metabolism*, by Wagner and Mitchell, (see p. 48 of this issue *Q. R. B.*) or the special survey of human biochemical genetics by Harris (*Q. R. B.*, 30: 392. 1955). So rapidly is insight advancing in all fields of biochemical genetics that the accounts given by Haldane are already considerably out of date, particularly in regard to the biosyntheses occurring in *Neurospora*, in bacteria, and in man.

The three final chapters of the book consider Extranuclear Influences on Biochemical Activity, including Training; Mutation, and the Problem of Gene Reproduction; and offer Tentative Conclusions. Here, where the questions are unanswered and the problems remain most speculative, Haldane is at his best—thought-provoking and challenging. The meaning of adaptation in biochemical terms; the relation of genes to enzymes; the relative complexity of the biochemical machinery in the higher plants and animals, rather than the commonly assumed greater simplicity than in yeast, bacterium, or mold; and the nature of progressive biochemical evolution, "not . . . by making enzymes and genes of a radically new character, but by broadening and narrowing their ranges of specificity, so that one enzyme in an ancestral form would be represented by a battery of enzymes in a descendant"—such conceptions should quickly fire controversies and stimulate experiments. To do that, rather than to survey biochemical genetics with thoroughness, was clearly the intention of the author, and he has undoubtedly succeeded in his aim, even if we might wish the book better balanced.

BENTLEY GLASS

TRAITÉ DE GÉNÉTIQUE. *Tome I, Le Mécanisme de l'Hérédité Génétique Formelle. Tome II, La Génétique des Populations. "Euclide," Introduction aux Études Scientifiques, Biologie Animale.*

*By Ph. L'Héritier. Presses Universitaires de France, Paris.* (I) 1,500 fr. (paper); (II) 900 fr. (paper). (I) iv + 343 pp.; ill. (II) iv + ii + pp. 345–515; ill. 1954.

*Le Mécanisme de l'Hérédité: Génétique Formelle* is the first of a series of three volumes included under the general title of *Traité de Génétique*. In its compactly written 343 pages the author presents the classic views of heredity and at the same time brings the reader up to date on the progress of genetical work in the past decade. The second volume of the series is devoted to the genetics of populations; the third, to the recent work in physiological genetics.

The author begins with a historical review of the work of Naudin, Weismann, and Mendel, "the first statistical biologist," pointing out that Mendel deliberately chose peas as they provide favorable material for genetic analyses. The unfavorable nature of *Hieracium* for such studies was a discouraging feature of Mendel's later experiments. A summary of the work of the great pioneers in genetics and a discussion of the Lysenko controversy complete the chapter.

The second chapter, entitled Classic Mendelism, covers the elementary genetical facts. An excellent example of Mendel's first law, not usually seen in textbooks, is Sosa-Bourdouil's case of segregation in rice or corn plants heterozygous for a pair of alleles determining synthesis of starch vs. dextrines, as seen in the pollen grains with suitable stains. Included here is a careful discussion of the interaction of genes and environment in determining the phenotype, the phenomenon of penetrance, hybrid vigor, and transgression. Mather's polygene theory is presented interestingly, but it is not fully accepted by the author. There is a short statistical treatment of crossing-over and methods of detecting it in rabbits and peas.

The third chapter, entitled The Chromosomal Theory of Heredity, considers the cytological proof that the chromosomes are the hereditary material and genetical and cytological proofs of the linear arrangement of the hereditary material. The author reviews Caspersson's study of the structure of the chromosome and the difference between euchromatin and heterochromatin, saying that most geneticists now feel that heterochromatin has a less specific role than euchromatin. There is a rather detailed discussion of crossing-over and its relation to cytological chiasmata, the author pointing out that there is occasionally a weak interference at the level of the chromatids resulting in slightly more than 50% recombination in some cases. Darlington's theory and that of White on the nature of crossing-over are presented.

Chapter IV, entitled Hereditary Facts on the Chromosome Level, includes a discussion of balanced lethals, chromosome rearrangements, and the relation of these to meiosis. A short explanation of position effect, polyploidy, and aneuploidy concludes this section. In connection with the latter the author presents a brief outline of the inheritance of sex in *Drosophila*

and *Melandrium*. It is surprising that this subject is not discussed further in the volume.

Chapter V, Hybridization Between Species, summarizes a vast literature from plant and animal studies. The only *Drosophila* species crosses quoted are those first studied; i.e., the *melanogaster-simulans* cross and crosses within the *obscura* group analyzed by Dobzhansky. The author further takes up maternal effects, sterility of interspecific hybrids, allopolyploidy and its importance to man, particularly in the case of the evolution of bread wheat.

The last chapter, entitled Mutations, Their Spontaneous Appearance and Experimental Production, is the most interesting of the entire book. It deals in considerable detail with the spontaneous and artificial induction of gene mutation, "tiny" rearrangements, including up to 15 bands of salivary chromosomes in *Drosophila*, and gross rearrangements. McClintock's "break, fusion, break" cycle, accounting for mottling in maize owing to position effect, is described briefly and the author points out that the same sort of phenomenon may account for mottling at the white locus in *Drosophila*. In discussing ionizing rays and mutation the author emphasizes that dosage is the only characteristic of ionizing rays capable of influencing mutation frequency, the latter being linearly proportional to the dosage. The effects of the physiological state of the cell, temperature, oxygen tension, and pretreatment of cells with infra-red radiations in connection with X-ray, gamma ray, and ultra-violet treatments are considered in detail. Finally there is a discussion of the induction of gene mutation by chemical substances. In contrast with the action of ionizing rays, chemical substances (1) exert a delayed effect, and (2) produce a much greater number of gene mutations and "tiny" rearrangements compared with gross chromosomal rearrangements than x- or gamma rays, probably because after breakage, conditions for fusion of broken ends are not as favorable as after treatment by ionizing rays. The author expresses a preference for Goldschmidt's theory that large or small changes in the structure of the chromosome result in a change in its functioning which corresponds phenotypically to a position effect. The natural agent causing mutation may be temperature changes, according to the author.

There are excellent literature references at the conclusion of each chapter. If any reader feels that a subject might be considered in more detail, he should remember the scope of this text. The author's style is never redundant, and it is the reviewer's opinion that more information is included in this work than in comparable texts in English. Unfortunately, the book is only paper-bound, like other publications of the Presses Universitaires de France, and the pages are uncut. Line drawings are quite adequate as illustrations. No doubt for economic reasons the external appearance of this text belies the excellence of what is within.

SARAH B. PIPKIN

GENETICS & HUMAN HEREDITY.

*By J. Ben Hill and Helen D. Hill. McGraw-Hill Book Company, New York, Toronto, and London.* $6.50. xiv + 526 pp.; ill. 1955.

There are a number of both good and poor genetics textbooks available on the present market. This volume seems to fall into an intermediate position as regards quality, comprehensiveness, uptodateness, and clarity. It covers a good deal more territory than does Snyder's *Principles of Heredity*, yet lacks the clarity that characterizes that book. It is, on the other hand, far more extensive than Winchester's volume, at the same time that it falls far below it in the quality of its illustrations. Many of the figures, taken from other sources rather than being original, are murky and indistinct. To extend the comparison with existing textbooks, *Genetics and Human Heredity* is not the equal of either the Sinnott, Dunn, and Dobzhansky or the Srb and Owen volumes, and it is not recommended over either of them. Many of the more modern aspects of genetics are omitted or only briefly mentioned; this includes such topics as biochemical genetics, bacterial heredity, cytochemistry, pseudoallelism, population dynamics in the sense of Dobzhansky, and heterochromatin. It hardly seems possible to give a modern point of view without giving some emphasis to current ideas.

The title of this book is also misleading. The amount of space devoted to human heredity, which is confined to the last couple of chapters, hardly warrants the inclusion of *Human Heredity* as part of the name of the book. If it is intended that the book be used for courses in human heredity, then the volumes of Stern and Neel are to be preferred.

In general, the volume is competent enough for the average student of genetics, but because there are better textbooks available it is not one which the reviewer would select for a course in either general genetics or human heredity.

C. P. SWANSON

BIOLOGIE CELLULAIRE.

*By A. Obré, F. Campan, and R. Chanton. G. Doin & Cie., Paris.* 1,500 fr. (paper). 334 pp.; ill. 1954.

Compiled as a study manual for students preparing for certification at the Grandes Écoles Biologiques and Écoles Normales Supérieures, the format and content of *Biologie Cellulaire* are quite similar to what might be expected in a College Outline treatment of general cytology and cellular physiology at the beginning graduate level. It is of wide compass, necessarily brief

and direct, aiming to provide students with summary evidence and ready answers. References direct the student wishing more critical discussion of special topics to leading French texts of recent publication date. It is of interest to biologists chiefly as an indication of the formal training in cellular biology given French students who are candidates for a rough equivalent of the Master's degree.

K. W. COOPER

INTERNATIONAL REVIEW OF CYTOLOGY. *Volume IV. Prepared Under the Auspices of The International Society for Cell Biology.*

*Edited by G. H. Bourne and J. F. Danielli. Academic Press, New York.* $9.00. xii + 419 pp.; ill. 1955.

Volume IV of this series continues the presentation of pertinent topics of current interest characteristic of the three earlier volumes. This is not an easy task, for good reviews are hard to come by, and the editors are to be commended for the high standards which have been maintained. The distribution of subject-matter is likewise balanced, providing thereby a means for bringing into closer juxtaposition the related fields of cytology and cellular physiology. The following topics are discussed: cytochemical micrurgy of free cells such as amoebae, marine invertebrate eggs, and ascites tumor cells (Kopac); amoebocytes of the mollusk (Wagge); problems of fixation in cytology, histology, and histochemistry (Wolman); bacterial cytology (Marshak); the histochemistry of bacteria (Vendrely); plant mitochondria (Hackett); the structure of chloroplasts (Muhlethaler); the histochemistry of nucleic acids (Kurnick); the structure and chemistry of nucleoli (Vincent); mammalian goblet cells (Moe); the localization of cholinesterases at neuromuscular junctions (Couteaux); and evidence for a redox pump in the active transport of cations (Conway). The importance of any particular article and the completeness with which the field is covered can only be judged by those working in those immediate areas, but to me the papers by Kopac, Hackett, Muhlethaler, and Vincent seemed particularly instructive.

C. P. SWANSON

VARIATION AND GENETIC RELATIONSHIPS IN THE WHITLAVIA AND GYMNOBYTHUS PHACELIAS. *Univ. Cal. Pub. Bot., Vol. 28, No. 2.*

*By George Willson Gillett. University of California Press, Berkeley and Los Angeles.* $1.00 (paper). iv + pp. 19–78; ill. 1955.

THE HEREDITY OF THE DIMENSIONS, THE WEIGHT AND THE INDICES (SIZE AND FORM) OF THE SEEDS OF *PHASEOLUS VULGARIS.*

*By G. P. Frets. Martinus Nijhoff, The Hague* Guilders 7.60 (paper). ii + 80 pp. + 1 table; ill. 1954.

## GENERAL AND SYSTEMATIC BOTANY

CRYPTOGAMIC BOTANY. *Volume II. Bryophytes and Pteridophytes. Second Edition.*

*By Gilbert M. Smith. McGraw-Hill Book Company, New York, Toronto, and London.* $8.00. vii + 399 pp.; ill. 1955.

The first edition of this 2-volume work was published in 1938, and was soon recognized as the standard textbook to cover these sections of the plant kingdom. The second edition maintains the same high standards of the first in text and illustration while at the same time it has been brought up to date. The range of material covered is, of course, enormous, and the principal discussions deal with distribution, structure, and reproduction. Except in a very general way, phylogenetic relationships and evolutionary trends are not considered, although the inclusion of such information in the form of a survey chapter would greatly enhance the usefulness of the volumes and would lift them out of the category of books which are content merely to enumerate the various divisions of the plant kingdom. On the other hand, a tremendous amount of material is assembled in these two volumes, and presented in a lucid and straightforward manner.

C. P. SWANSON

MARINE LITTORAL DIATOMS OF BEAUFORT, NORTH CAROLINA. *Duke Univ. Mar. Sta. Bull., No. 6.*

*By Friedrich Hustedt. Duke University Press, Durham.* $2.25 (paper). iv + 67 pp.; ill. 1955.

THE GENUS *OREOMYRRHIS* (UMBELLIFERAE). *A Problem in South Pacific Distribution. Univ. Calif. Pub. Bot., Vol. 27, No. 6.*

*By Mildred E. Mathias and Lincoln Constance. University of California Press, Berkeley and Los Angeles.* $1.00 (paper). ii + pp. 347–416 + 1 folded map; ill. 1955.

## PLANT MORPHOLOGY

CONTRIBUTIONS TO PLANT ANATOMY.

*By Irving W. Bailey. Chronica Botanica Company, Waltham; Stechert-Hafner, New York.* $7.50. xxvi + 259 pp. + 23 pl.; text ill. 1954.

It is with mixed emotions that one views the publication of a scientist's collected papers. One welcomes the grouping of such papers under a single cover, since the

subject of a scientist's research generally has a unity and a completeness about it that overcomes the disjointedness that inevitably creeps into a topic that spans not only the years but also a number of journals. On the other hand, a collection of papers has a certain finality about it. One hears, as it were, the tolling of the bell, and a sadness accompanies the termination of a career that has been productive, stimulating, and tinged with greatness.

I. W. Bailey is the acknowledged dean of plant anatomists, and there are few in the field who have not been influenced by him either by direct stimulus or, indirectly, through his published works. His publications cover a period from 1909 to 1953, with few annual exceptions. The arrangement of the papers in the volume is not chronological, however, but follows a more natural subdivision into subject matter. These are as follows: (1) cytology and ontogeny, in which Bailey's classical papers on the cambium and its derivative tissues are grouped; (2) biochemistry and biophysics, which include his collaborative studies on the ultrastructure of cell walls; (3) phylogeny, in which the evolution of vessels and tracheary tissue is discussed; (4) taxonomy, in which the techniques of wood anatomy are brought to bear on the systematic position of the Degeneriaceae and Winteraceae and the specializations of the dicotyledonous carpel; (5) entomology, in which the ant-plants are dealt with; (6) paleobotany, which is concerned with the woods of Mesozoic conifers; (7) wood technology, in which the basic knowledge of wood structure has been of assistance in determining methods of preservation; and (8) cooperation in scientific research, in which the role of research in forestry is discussed. A good many of Professor Bailey's papers have been left out, but those included are sufficient to indicate the influence he has had in the field of plant morphology, and the contributions he has made. It is, moreover, a synopsis of a career which has been characterized by innovation, for Bailey perhaps more than any other plant anatomist has been instrumental in bringing new techniques and ideas into a field that was threatened with stagnation. The collected papers, therefore, reflect his attempts to bridge the gaps between plant anatomy and other related fields such as cytology, morphogenesis, evolution, and taxonomy. Few would dispute the solidness of his contributions, but more enduring even than these are the continuing studies of his collaborators and students who, guided and inspired by him, expand the fields of research which he opened to them.

C. P. SWANSON

## ECONOMIC BOTANY

DISEASES OF VEGETABLES. *Bull. Minist. Agric. Lond., No. 123. By Lawrence Ogilvie. Her Majesty's Stationery Office, London, for the Ministry of Agriculture and Food Fisheries, London.* 4s. (paper). iv + 80 pp. + 12 pl. 1954.

## GENERAL AND SYSTEMATIC ZOOLOGY

MARINE SHELLS OF THE WESTERN COAST OF FLORIDA. *By Louise M. Perry and Jeanne S. Schwengel; with revisions and additions to Louise M. Perry's Marine Shells of the Southwest Coast of Florida; illustrations by W. Hammersley Southwick, Axel A. Olsson, and Frank White. Paleontological Research Institution, Ithaca.* $7.00 (cloth); $6.00 (paper). 318 pp. + 1 pl.; text ill. 1955.

This is a revised edition of a book which first appeared some years ago. It is now well known and any attempt to evaluate it in this review would be superfluous. Although the book is intended primarily for collectors rather than for students of life processes—and for beginners at that—the introductory chapters contain much data concerning matters of which I found myself ignorant, and I can enthusiastically recommend this part of the work even to advanced scientists. We are badly in need of a work similar to this to deal with the identification of the commoner shells of the Californias and the "Vermilion Sea."

JOSHUA L. BAILEY, JR.

THE EVOLUTION OF AN INSECT SOCIETY. *By Derek Wragge Morley. Charles Scribner's Sons, New York.* $3.95. 215 pp. + 31 pl. 1955.

When ants are your passion, it must be a torment to attempt a sober, strictly factual account of an ant colony's activities, for there is so much in their lives to fire fancy and to set the mind a-bounding. Morley spared himself this torment, and the result is an entertaining, albeit a somewhat whimsical and florid, biographical interpretation of a 40-year-old commune of *Formica rufa* in an English woods. Despite certain quasifictional aspects of the text, and its anthropomorphic cast (which Morley denies), the book is on the whole instructive, and one which the devoted nature lover will enjoy. Professional entomologists will, I think, be less pleased, for in both text and illustration there is much with which one may properly take issue.

Most aspects of ant life are touched upon in this book and, where the commune of wood ants is specifically concerned, description and discussion range to considerable length. The origins of ants, the supposed evolution of formicine ants from ponerine types, no less the evolution of behavior and societal patterns, nest founding and architecture, foraging and feeding activities, brood rearing, division of labor, conflict

among ants, social parasitism, and so on, are all dwelt upon in admiring fashion. The general theme developed by Morley is that the ants of the commune (namely the collection of sister nests interconnected with the mother nest and each other by trails) are held together in a society by their common "odor badges," by mutual feeding, by the pressures of common work, by the brood and enormous fecundity of the numerous queens, by "interacting instincts," and so on. Perhaps the chief addition to the list of factors influencing societal behavior in wood ants, evidently uniquely Morley's own and which readers of his *Ant World* will recall, is that of the so-called "excitement center ants" which are said to serve as pacemakers and guides of the nest's activities.

On the debit side of the ledger are the loose, wholly inaccurate, or implausible statements which are scattered throughout the text. As examples, consider the statement of consequences to the male, as though fact, assumed to have followed as results of an increased fertility of queens (pp. 57 et seq.), or the incredible account of neurons given on pp. 147–148, or the fanciful little tale of the doings of a certain three-year-old worker (p. 23 et seq.). The posed illustration of Two Primitive Burmese Formicine Ants at Play (Fig. 12) is at best regrettable, and the illustrations of *Colobopsis* (Fig. 13a), *Myrmecia* (Fig. 15a), and *Eusphinctus* (Fig. 15b) are perhaps the very worst of ants that have ever been favored with half-tone reproduction. The ant of Fig. 13b is properly called *Lasius niger*, and not, as labelled, *Acanthomyops niger*; finally, Fig. 16a is upside down. It is too bad the book is so noticeably blemished in these ways, for, despite its entertaining and well-organized text, it cannot be given a wholehearted recommendation.

KENNETH W. COOPER

TRAITÉ DE ZOOLOGIE. *Anatomie, Systématique, Biologie. Tome XII. Vertébrés: Embryologie, Grands Problèmes d'Anatomie Comparée, Caractéristiques Biochimiques.*

*Under the direction of Pierre-P. Grassé. Masson & Cie., Paris.* 10,550 fr. (cloth); 9,800 fr. (paper). viii + 1145 pp.; ill. 1954.

The twelfth volume of the great *Traité de Zoologie* deals exclusively in generalities (in the best sense) concerning the group of vertebrates as a whole. It is divided into 4 principal sections. The first (Brien and Dalcq) deals rather briefly with the general characters of vertebrates and the basic principles of their morphology and evolution. The second (Dalcq and Pasteels) considers at somewhat greater length general problems of morphogenesis and development in vertebrates. The greater part of the volume is devoted to comparative anatomy (central nervous system, Cordier; eye, Rochon-Duvigneaud; ear, Cordier and Dalcq; olfactory organ, Gérard; skull, Piveteau; vertebral column, ribs, sternum, origin and evolution of fins and limbs, Devillers; teeth, Lison; circulatory system, Stéphan; urinogenital organs, Gerard). The chapters in the section entitled Comparative Anatomy include, however, as must all sound morphology, a wealth of information concerning the development of the organ-systems discussed. The first three sections together, therefore, constitute a well-knit unity. Two very short chapters, one on chromosomal morphology (Matthey), and another on selected biochemical characteristics (Florkin), bring up the rear; since these are rather specialized, and not directly related to the rest of the main contents of the book, they will not be considered further in this review.

The whole is said to be more than the sum of its parts, and this volume is more than a collection of usual textbook chapters. Its sections are thoughtfully and elegantly composed; almost all of them are written with considerable spirit, and a number of them with real imagination. It is, for instance, refreshing indeed to find that an introductory chapter on vertebrate characteristics can in the mid-1950's be sufficiently alive to effect a new synthesis between concepts of morphology and of evolution on the basis of modern experimental findings in embryology. The chapter devoted solely to development accomplishes in a short space a masterly synthesis within the welter of heterogeneous detail which passes for the substance of contemporary embryology. The section on comparative anatomy has been criticized in some quarters for its omission of some organ-systems. Those which are included are, however, most of the ones which are closely involved in the coordination of the organism as a whole; and in any case, since the volume differs so profoundly in character, most especially in its originality, from the usual formalized American textbooks and German treatises on comparative anatomy, it deserves to be assessed for what it contains rather than for what it never attempts to cover. The contents are accurate, up to date, and quite magnificently illustrated.

The larger divisions of the *Traité*, which eventually will number 17 volumes, will include only 2 devoted to such general considerations, one for the insects, and this one for the vertebrates. Since the insects will hardly be in a position to appreciate theirs, it is to be hoped that the vertebrates will value their own doubly. This volume deserves to be read and owned and enjoyed by all who concern themselves with the problems of vertebrate organization.

JANE OPPENHEIMER

SYSTEMATICS AND ZOOGEOGRAPHY OF PHILIPPINE AMPHIBIA. *Philippine Zoological Expedition, 1946-1947. Fieldiana: Zool., Vol. 33, No. 4.*

*By Robert F. Inger. Chicago Natural History Museum, Chicago.* $6.00 (paper). Pp. 183–531; ill. 1954.

This is a most painstaking and thorough review of the amphibians of the Philippines. Although 1800 amphibians collected by a Chicago Natural History Museum expedition in 1946–47 provided the impetus for the present work, Inger has fully utilized other available collections and the pertinent literature.

The first part of the book comprises an interesting introduction with information on the climate and vegetation of the Islands and a summary of the taxonomic history of the amphibian fauna. The bulk of the volume consists of an account of the 82 recognized forms (5 of which are new) in which many detailed observations are included. Well-drawn figures, informative tables, and identification keys supplement the text. The fauna consists almost completely of frogs and toads. There is one coecelian and there are no salamanders. The final 60 pages are devoted to a penetrating essay on the zoogeography of the Philippine amphibia. There is a list of references and an index. This volume is a competent, scholarly work.

While the actual zoological details are probably too technical for notice here, one matter which came to my attention is probably general enough to deserve a comment. I recognize at the outset that I may have actually read into Inger's remarks something neither intended nor implied. While the present work is modern and defensible, one may gather from perusing it that earlier studies did not meet such high standards. I do not suggest that an investigator be less than critical of previous works, for that is clearly one of his important responsibilities. I am, though, questioning whether it is fair to reflect unfavorably upon an earlier student because he did not use modern concepts and procedures.

It is clear that in this regard Inger makes factual statements and is not necessarily giving value judgments. Yet the implications are there, nonetheless, and careful readers will see in his remarks such apparent evaluations of previous workers. Too many of our graduate students and younger investigators, with superior accumulations of literature and specimens than their predecessors possessed, are prone to discount earlier contributions to systematic zoology. They seem to lose sight of the fact that it is first necessary to survey an area to find out what kinds of animals are present before comprehensive systematic and distributional studies can be made. They do not always recognize that their own work will almost certainly not prove to be definitive. They fail to realize that a new series of concepts and procedures in systematic zoology has grown up in our generation. They seem to forget that the literature and many of the specimens upon which their work is based are due to the efforts of investigators before them. I hope it is not impertinent to point out that the only clear-cut advantage present-day workers have over their predecessors lies in their accumulated experience.

I do not intend for these last remarks to detract from the merit of the study under review in any way. Inger's book will be a standard work for many years and will be referred to, with profit, by a wide variety of zoologists.

A. B. Grobman

Karl Patterson Schmidt Anniversary Volume *In Honor of His Sixty-Fifth Birthday. Fieldiana: Zool., Vol. 37.*

*Chicago Natural History Museum, Chicago.* $10.00 (paper). viii + 728 pp.; ill. 1955.

In honor of the scientific reputation of K. P. Schmidt, and in recognition of his achievements in the division of zoology, the scientific staff of the Chicago Natural History Museum has produced this anniversary volume on the occasion of his retirement from active administrative duty. As it was felt to be more appropriate for his colleagues to participate, rather than to devote the volume to his particular zoological speciality, each member of the research staff has contributed one research paper. In all, 27 separate articles are included, covering such diverse areas as paleontology, entomology, comparative anatomy, and ecology. The articles are similar in length and scope to those usually appearing in scientific journals, and there is no subject continuity throughout the book, except that expressed in the Introduction, which dedicates the volume to the recognition of the honored zoologist.

Bryan P. Glass

The Genus *Eustala* (Araneae, Argiopidae) in Central America. *Bull. Mus. comp. Zool. Harvard Coll., Vol. 112, No. 6.*

*By Arthur M. Chickering. Museum of Comparative Zoology, Harvard College, Cambridge.* $1.35 (paper). ii + pp. 391–518; ill. 1955.

This monograph, dealing with one group of orbweaving spiders, is the latest of a series of papers concerned with Panama and Central America, of which the first appeared in 1937. The work is entirely of a taxonomic nature, and the greatest part of the material considered was collected by the author himself. A total of 38 species is included, and of these 26 are indicated as new to science. The descriptions are quite detailed and are accompanied by 140 drawings illustrating important diagnostic characters. Unfortunately, the author gives no indication of the relation of the genus to other neighboring genera, nor does he show its position within the subfamily to which it belongs; and he

completely omits a discussion of the characters diagnostic of the genus *Eustala* itself.

B. J. KASTON

THE MAMMAL GUIDE. *Mammals of North America North of Mexico.*

*By Ralph S. Palmer. Doubleday & Company, Garden City.* $4.95. 384 pp. + 40 pl.; text ill. 1954.

Among the considerable number of guides to the species of North American mammals that have appeared in recent years, this one by Ralph Palmer will find an accepted place. It communicates far more knowledge to the reader than any of the others that the reviewer has had the opportunity to peruse. Every species or species group is dealt with under the headings of general remarks, description, habitat, reproduction, habits, and economic status. It is understandable that for some species these headings may have very little information to offer and in some groups are treated more or less at the generic level. In every case a complete listing of the currently recognized species is given. The common names used comply in general with those most commonly accepted by mammalogists, and other vernacular names are frequently also listed. The distribution of each species is plotted on a map, and in most cases these are accurate, although it is natural in a book of this scope that minor inaccuracies, detectable only to a local specialist, should occur. There is a series of 40 color plates, which are all concentrated in the middle of the book. To the reviewer the color plates are the big disappointment of the book, for they are, in most cases, too highly colored and without texture, although the attitudes of the creatures are quite lifelike.

Inside the front and back covers of the book are maps depicting the major vegetation zones in North America. Residents of Texas and Louisiana may be alarmed to find that the southern pine forest has receded eastward into the State of Mississippi, but otherwise the zones seem to be accurately defined.

For a rapid reference to the factual data on any species of mammal on the North American continent this book should be useful. Amateur naturalists will especially appreciate the natural history data that are much more complete than in most other manuals.

BRYAN P. GLASS

LABORATORY MANUAL OF MAMMALOGY.

*By E. Lendell Cockrum; illustrated by R. B. Chiasson and Frances Wimsatt. Burgess Publishing Company, Minneapolis.* $4.00 (paper). v + 160 pp.; ill. 1955.

To call this book a laboratory manual is somewhat misleading, for it is more nearly an outline for a course in mammalogy. My first impression was that for the amount of material presented there was remarkably little for a student actually to perform. On reading the text more carefully one finds numerous things that the student *may* do, but not the qualities that go to make up a manual in the strict sense, the telling of the student specifically what to do and how to do it. Actually it is in one of the appendices that the biggest laboratory assignment is made, the execution of definitely prescribed field problems.

As far as giving information is concerned, the book is loaded with information of great importance to a student mammalogist. The first 3 chapters are devoted to the classification, morphology, and identification of mammals. Here is found a list of many of the measurements and other technical morphological characters with which the tyro mammalogist must become familiar, as well as identification keys and a glossary of technical terms. Unfortunately, in this section are also to be found several statements that are debatable. Twice the kangaroo rats are described as having inflated bullae, whereas it is actually the mastoids that are inflated (this is correctly explained in the glossary); the term "tuberculosectorial" is used as a descriptive adjective describing the crushing and cutting teeth of the dog—an unfortunate choice of terminology, since the word is also frequently used as an alternative for the primitive tribosphenic teeth of pantotheres and of many modern marsupials and insectivores. Elsewhere a premolar formula of 1:1 is attributed to *Zapus*, obviously a typographical error, and the manatee is described as lacking nasal bones (nasals may be lacking in individual manatees, but are uniformly absent only in Steller's sea cow, now extinct). The keys to families and genera are uniformly excellent.

Subsequent chapters deal with pelage, hair structure and molting, geologic history of mammals, and distribution and migrations. This discussion primarily concerns North America, although the principles apply everywhere. Chapters follow on life history study methods, hibernation, territoriality, reproduction, and population dynamics.

BRYAN P. GLASS

A REVIEW OF THE NOTOSTRACA. *Bull. British Mus. (nat. Hist.), Zool., Vol. 3, No. 1.*

*By Alan R. Longhurst. British Museum (Natural History), London.* 12s. 6d. (paper). ii + pp. 1–57; ill. 1955.

AMPHIPODA COLLECTED AT THE ARCTIC LABORATORY, OFFICE OF NAVAL RESEARCH, POINT BARROW, ALASKA, BY G. E. MACGINITIE. *Smithson. misc. Coll., Vol. 128, No. 1.*

*By Clarence R. Shoemaker. Smithsonian Institution, Washington.* 75 cents (paper). ii + 78 pp.; ill. 1955.

REVISION OF THE FLEA GENUS *PEROMYSCOPSYLLA*. *Smithsn. misc. Coll., Vol. 123, No. 4. (Pub. 4178).*

*By Phyllis T. Johnson and Robert Traub. Smithsonian Institution, Washington.* 65 cents (paper). ii + 68 pp.; ill. 1954.

THE BLOWFLIES OF CALIFORNIA (*Diptera: Calliphoridae*). *Bull. Calif. Insect Surv., Vol. 4, No. 1.*

*By Maurice T. James. University of California Press, Berkeley and Los Angeles; [Cambridge University Press, London].* 50 cents (paper). ii + pp. 1–34; ill. 1955.

STUDIES OF NEARCTIC *COENONYMPHA TULLIA* (RHOPALOCERA, SATYRIDAE). *Coenonympha tullia inornata* Edwards. *Amer. Mus. nat. Hist. Bull. Vol. 105, Art. 4.*

*By F. Martin Brown. American Museum of Natural History, New York.* 75 cents (paper). iv + pp. 359–409; ill. 1955.

THE CARPENTER BEES OF CALIFORNIA (*Hymenoptera: Apoidea*). *Bull. Calif. Insect Surv., Vol. 4, No. 2.*

*By Paul D. Hurd, Jr. University of California Press, Berkeley and Los Angeles; [Cambridge University Press, London].* 50 cents (paper). ii + pp. 35–72; ill. 1955.

REVISION OF THE VITTATE SPECIES OF THE CHRYSOMELID BEETLE GENUS *DISONYCHA* FROM THE AMERICAS SOUTH OF THE UNITED STATES. *Proc. U. S. nat. Mus., Vol. 104, No. 3338.*

*By Doris Holmes Blake. Smithsonian Institution, Washington.* Free upon request (paper). 86 pp.; ill. 1955.

A REVISION OF THE GENUS *TROX* IN NORTH AMERICA (COLEOPTERA, SCARABAEIDAE). *Bull. Amer. Mus. nat. Hist., Vol. 106, Art. 1.*

*By Patricia Vaurie. American Museum of Natural History, New York.* $1.25 (paper). 89 pp.; ill. 1955.

RECORDS OF FISHES IN THE JOHN N. LOWE COLLECTION FROM THE UPPER PENINSULA OF MICHIGAN. *Misc. Publ. Mus. Zool. Univ. Mich., No. 87.*

*By William Ralph Taylor. University of Michigan Press, Ann Arbor.* 50 cents (paper). 50 pp.; ill. 1954.

## ECONOMIC ZOOLOGY

ORGANIC INSECTICIDES. *Their Chemistry and Mode of Action.*

*By Robert L. Metcalf. Interscience Publishers, New York and London.* $8.50. x + 392 pp.; ill. 1955.

In this book, Robert L. Metcalf has added greatly to the Metcalf reputation for distinguished contributions to entomology set by his father, C. L. Metcalf. Robert L. Metcalf is relatively young in science, and yet six years ago he was asked to prepare the first monograph published by the Chemical-Biological Coordination Center of the National Academy of Sciences–National Research Council in Washington. This was entitled, *The Mode of Action of Organic Insecticides.*

He has now repeated his success with a brilliant book on the chemistry and mode of action of insecticides. The basic organization of the book is chemical. He has assigned one chapter for each of 11 groups of compounds, from the classical nicotine to the recent cyclodienes and organic phosphorus insecticides. The organization of each chapter follows the order—chemistry, relation of structure to activity, mode of action, and mammalian toxicology.

Metcalf has gone farther than any other person in his field to elevate to prominence the physiological action of the compounds, but he still has not quite broken the shackles of the chemist's view. He still takes a chemist's view of the problem, which is curious, in view of his basic training as a biologist.

In only one chapter has Metcalf taken the insect's-eye view of insecticides, in a chapter in which he discusses the resistance of the insects to insecticides. Even this chapter is entitled Insecticide Resistance rather than Resistance to Insecticides.

I for one would wish that Metcalf would soon write for us biologists another book covering the effect of compounds on insects in terms of nerves, circulation, digestion, reproduction, and the like. In the meantime, let us be thankful to have on our shelves a book so beautifully done.

JAMES G. HORSFALL

ANALYSIS OF INSECTICIDES AND ACARICIDES. *A Treatise on Sampling, Isolation, and Determination including Residue Methods. Chemical Analysis: A Series of Monographs on Analytical Chemistry and Its Applications, Volume VI.*

*By Francis A. Gunther and Roger C. Blinn. Interscience Publishers, New York and London.* $14.00. xii + 696 pp.; ill. 1955.

Food grown by farmers feeds both bugs and man—and bugs hold a ticket for the first sitting. Were the bugs not restrained, they would gobble so much of the food that little would be left for man. The farmers restrain the bugs by poisoning them, and this tends to contaminate the food supply left for man to consume.

Many persons have worried about the damage to man that might ensue from ingesting such poisons. After much travail Congress passed, a year or so ago, the famous Miller bill. As usual, this bill offered a compromise between the shrill yapping of the psychoceramics (crackpots), who would outlaw all sprays on foods, with the deeper-toned opinions of those who advise that without pesticides, food would be in short supply.

This compromise was reasonable. Pesticides can be used to an extent consonant with a low residue on the food when harvested. After all, the action of sun, wind,

and rain rapidly reduces the residue after the bugs are killed. The Miller bill wisely does not worry about residues during the season, but only about those at the end. Tolerances for all useful pesticides are therefore being set.

How does one determine the residue? This now becomes a very important practical problem. Gunther and Blinn have addressed their vast experience to it and have beautifully brought together the known techniques of chemical assay. They have divided their book into three sections: Problems in Obtaining Quantitative Residue Data; Problems in Analyzing Technical Grade Materials and Formulated Products; and Sampling, Measuring, Processing, Cleanup, and Analytical Methods. The book concludes with a very useful appendix of ultraviolet and infrared spectra for the products to be analyzed.

For those who must be concerned with insecticides on food crops, this book is a godsend. It is modern and complete.

JAMES G. HORSFALL

FUN WITH GAME BIRDS. *Bird Hunting in Words, Paint & Lines.*

*By Fred Everett. The Stackpole Company, Harrisburg.* $7.50. 287 pp. + 5 pl.; text ill. 1954.

The author-artist of this volume could have produced it only after a long and intimate acquaintance with the grouse, quail, woodcock, turkey, and pheasant of which he writes—their territory, habits, appearance, and personality. The words and sketches reveal as much, but this is only a part of what enters into a thoroughly delightful volume. There is, as well, that indefinable pleasure to be found in the field and along the stream, the comradeship of congenial companions, and the kinship between hunter and quarry. These add up to a quality that permeates the volume, and sets it apart as something more than just another well-illustrated, well-written, nostalgic hunting story.

HISTOIRE DES ANIMAUX. *Leur Influence sur la Civilisation Humaine.*

*By Richard Lewinsohn. Librairie Plon, Paris.* 1,800 fr. (cloth); 1,200 fr. (paper). ii + 406 pp. + 32 pl.; text ill. 1953.

Lest the title of this book mislead anyone into thinking of it as a survey of the history and evolution of animal life, it may be well to state at the outset that it deals with the story of the various kinds and degrees of influence animal life has had on human culture and civilization. It deals with animals as objects of food and the chase, as beasts of burden, as sport (such as bull-fighting, horce-racing, etc.), as material for art and for study (including scientific study), as objects to be raised and selectively improved and even protected, and as symbols by which to convey human fears and hopes, thoughts and yearnings, otherwise directly inexpressible. The author divides his survey into six periods: the Prehistoric, Antiquity and Middle Ages, the Age of Discovery, the Age of Ideas, the Age of Machines, and the Age of Chemistry. For example, in the last period there are included accounts of such diverse topics as artificial insemination, Gandhi and the Sacred Cow, synthetic textiles made of cellulose, and Japanese cultured pearls. Throughout, the author has gathered items from far and wide, but the resulting presentation gives one the feeling that while there is much interesting material here, it is only slightly digested and integrated, and also that the gathering has been more a matter of random sampling than a thorough survey. It is only in this way that it seems possible to account for such serious omissions as all mention of the medieval bestiaries and their original fountain-head, the *Physiologus*, of the advent into European culture of the wealth of Sanskrit animal tales through the Bidpai or the Panchatantra, or of the similar infiltration of Egyptian animal hieroglyphs through the compilations of Horrapollo. As it is, the book is pleasant browsing, but it makes one wish it were more inclusive.

HERBERT FRIEDMANN

COMMON INSECT PESTS OF STORED FOOD PRODUCTS. *A Guide to Their Identification. 3rd Edition. Brit. Mus. (nat. Hist.), econ. Ser., No. 15.*

*By H. E. Hinton and A. Steven Corbet. British Museum (Natural History), London.* 2s. 6d. (paper). vi + 61 pp.; ill. 1955.

FLUCTUATIONS IN GROWTH AND YEAR-CLASS STRENGTH OF THE WALLEYE IN SAGINAW BAY. *Fish. Bull. U. S., Vol. 56, No. 91.*

*By Ralph Hile. U. S. Department of the Interior, Fish and Wildlife Service, Washington.* 35 cents (paper). ii + pp. 7–59; ill. 1954.

DISTRIBUTION AND ABUNDANCE OF EGG AND LARVAL POPULATIONS OF THE PACIFIC SARDINE. *Fish. Bull. U. S., Vol. 56, No. 93.*

*By Elbert H. Ahlstrom. U. S. Department of the Interior, Fish and Wildlife Service, Washington.* 40 cents (paper). ii + pp. 83–140; ill. 1954.

LARGEMOUTH BASS IN RIDGE LAKE, COLES COUNTY, ILLINOIS. *Bull. Ill. nat. Hist. Surv., Vol. 26, Art. 2.*

*By George W. Bennett. Natural History Survey Division, Department of Registration and Education, State of Illinois, Urbana.* Free upon request (paper). iv + pp. 217–276; ill. 1954.

THE BALD EAGLE, *and Its Economic Status. Circ. U. S. Fish Wildl. Serv., No. 30.*

*By Ralph H. Imler and E. R. Kalmbach. U. S. Department of the Interior, Fish and Wildlife Service, Washington.* 30 cents (paper). iv + 51 pp.; ill. 1955.

## ANIMAL GROWTH AND DEVELOPMENT

UNTERSUCHUNGEN ÜBER DIE ENTWICKLUNG DER SCHÄDELFORM DES MENSCHEN UND EINIGER ANTHROPOIDEN. *Abhandlungen zur Exakten Biologie, Heft 3.*

*By Benno Kummer. Gebrüder Borntraeger, Berlin-Nikolassee.* DM 9.00 (paper). 44 pp.; ill. 1953.

## ANIMAL PHYSIOLOGY

ANNUAL REVIEW OF PHYSIOLOGY. *Volume 17.*

*Edited by Victor E. Hall; associate editors, Frederick A. Fuhrman and Arthur C. Giese. Annual Reviews, Stanford, and The American Physiological Society.* $7.00 (U. S. A.); $7.50 (foreign). x + 551 pp. + 1 pl. 1955.

This is the 17th volume of a series which has become an integral part of the working library of everyone concerned with any phase of biology and medicine. With the usual high standard of the series, this volume reviews a host of subjects, from transport through biological membranes and from developmental and environmental problems, to detailed systemic mammalian and comparative physiology. Special mention should be made of the prefatory chapter by F. C. Mann, a most interesting autobiographical report of the development of one of our most renowned experimental physiologists in medicine.

R. G. GRENELL

METABOLIC INTERRELATIONS *with Special Reference to Calcium. Transactions of the Fifth Conference, January 5–6, 1953, New York.*

*Edited by Edward C. Reifenstein, Jr.; editorial assistants, Shirley L. Wells and Beverly B. Turner. Sponsored by the Josiah Macy, Jr. Foundation, New York.* $5.00. 386 pp.; ill. 1954.

Like its predecessors, this volume provides a stimulating, often thought-provoking insight into the thinking of some of the leaders in the research of bone metabolism. A record of spontaneous comment and discussion cannot avoid some repetition. Interesting side-issues occasionally led to digressions from the set topics; and most chapters contain more information than their headings might suggest.

This symposium dealt with the factors that influence calcium absorption, metabolism, transport, and excretion. The parathyroid hormone, vitamin D, and citrate metabolism in relation to calcium were singled out for particular emphasis. However, as in previous conferences, the effects of pregnancy and lactation on calcium metabolism received scant mention. The currently popular topic of the interrelationship between the heavy trace metals and bone calcium metabolism was discussed and is reported in a separate chapter on chelating agents. The symposium included a discussion of the nature and properties of the bone mineral, a subject which has been considerably complicated by the recognition of several crystal types in bone.

The volume is enhanced by some excellent plates and contains a cumulative subject index to the Josiah Macy Jr. Foundation Symposia of 1949–53 on *Metabolic Interrelations*. The 1953 transactions offer a most palatable way of keeping abreast of many of the advances which have been made in our understandng of calcium metabolism.

CLAUDE F. BAXTER

TISSUE CULTURE TECHNIQUE IN PHARMACOLOGY. *Ann. N. Y. Acad. Sci., Vol. 58, Art. 7.*

*Edited by Roy Waldo Miner; consulting editor, C. M. Pomerat; 50 contributors. New York Academy of Sciences, New York.* $4.50 (paper). Pp. 971–1326; ill. 1954.

This series of papers is the result of a conference held in January, 1954, under the chairmanship of C. M. Pomerat and E. L. Severinghaus. Although formally concentrating on pharmacological applications of tissue culture methods, the papers contain a great deal of material of more general interest, which should appeal particularly to cytologists, general physiologists, and embryologists. The papers are divided into three sections. Part I consists of 10 papers on pure-strain, long-term and mass-culture methods, chemically defined synthetic media, the standardization of commercial media, and applications of tissue cultures in virology. Part II contains 8 papers on special assay techniques for drugs and hormones, with comparisons between results in vitro and in vivo. Part III presents 8 papers on the action of chemical agents on cell organoids and mitosis. The conference is a stimulating indicator of the progress made in the science and art of tissue culture since the pioneer studies of Ross Harrison in 1907 on the development of nerve fibres in vitro.

EVELYN HOWARD

NEUROPHARMACOLOGY. *Transactions of the First Conference, May 26, 27, and 28, 1954, Princeton, N. J. Edited by Harold A. Abramson. Sponsored by The Josiah Macy, Jr. Foundation, New York.* $4.25. 210 pp. + 1 folded table; ill. 1955.

The Macy Foundation has, for some years, done its best to encourage progress in biology and medicine through the support of various conferences. These discussion groups have been focused on areas in which either new ideas and pathways were necessary, or had already become apparent but needed clarification, direction, and attempts at integration with existing "fact" and theory. It was a logical consequence, then, to assume that the establishment of a series of conferences dealing with neuropharmacology would mean a new approach, and a fresh, provocative point of view.

Unfortunately, it is with great dismay that this reviewer must report that the first volume of neuropharmacological transactions makes his assumption invalid and his "logical consequence" illogical. The titles of the various discussion sections make it plain that the relationship of drug action to neural activity has been considered only from points of view previously expressed and discussed at length in other places. Some of these titles are: Functional Organization of the Brain; The Effects of Pharmacological Agents on the Over-all Circulation and Metabolism of the Brain; Ascending Reticular System and Anesthesia; and Electrical Activity of the Brain in Relation to Anesthesia. It is clear that a great deal of data and concept slightly redirected, or with the emphasis slightly reoriented, can be discussed by groups concerned with mechanisms of consciousness or of the nerve impulse or even of neuropharmacology. This general observation does not, of course, decrease the value or importance of the work involved any more than it overcomes the oft repeated superficialities and the absent new directions.

There is not space to examine each part of the conference in detail, nor would there be any particular value at this time in doing so. There is much useful information that will be of interest to many investigators working in any of several fields concerned with problems of the nervous system. Often throughout these presentations and discussions ancillary issues arise which are of great importance and merit serious consideration. One such instance can be found in the remarks of M. A. B. Brazier to the effect that electroencephalographers "... are always describing pen movement. Because they look alike, are they necessarily causally related?" Unfortunately, this type of problem is not followed up, so that it cannot accomplish what it should. This lack may or may not be a fault inherent in this type of discussion group. On the other hand, there is always the possibility that further consideration could have been stimulated by the chairman.

To me the most disappointing characteristics of the conference are two. The first is its complete neglect of the fundamental general physiological problems involved, the omission of physico-chemical data, concept, and theory. Nowhere is there any awareness of the role of molecular structure, orientation, and kinetics in the nerve cell membrane, a role which recent information would suggest is a vital part of any neuropharmacological mechanism. The second is the absence of any real consideration of the relationship of chemicals and drugs to psychological problems and behavior (despite the fact that this is stressed in the introductory remarks). It is hoped that the future meetings of this group will be oriented somewhat differently and will accomplish more of the kind of integration and productive speculation which has made other such discussions so profitable.

R. G. GRENELL

TEA. *A Symposium on the Pharmacology and the Physiologic and Psychologic Effects of Tea.* *Edited by Henry J. Klaunberg. The Biological Sciences Foundation, Washington.* $1.00 (paper). iv + 64 pp.; ill. 1955.

## ANIMAL NUTRITION

A DEVOTION TO NUTRITION. *By Frederick Hoelzel. Vantage Press, New York.* $2.50. vi + 88 pp. 1954.

In this book the author presents his experiences in nutrition from 1908–1953, during which time his philosophy changed from an unbelief in the importance of nutrition to a belief that increased mental and physical powers could be obtained by a control of nutrition. The author states: "To summarize, my observations convinced me that overhydration or an excessive retention of salt and water is the chief cause of common and generalized impairment of health." Furthermore, in the author's opinion, excessive salt-water retention is largely responsible for the development of common colds and self-consciousness. In subsequent chapters, the author expostulates on the desire to eat and its control; auto-intoxication, food restriction, fasting, and various diets.

This reviewer found the book monotonous and rambling. The possible good features are lost in a labyrinth of inconsequential and confusing personal impressions.

R. VAN REEN

WINE AS FOOD AND MEDICINE. *By Salvatore P. Lucia. The Blakiston Company, New York and Toronto.* $3.00. 149 pp. 1954.

Since time immemorial wine has been of importance in the life of man. While widely different views are held as to its proper place in our society, little information is normally found concerning the composition, physiological and therapeutic value of wines. This book by a Professor of Medicine at the University of California School of Medicine is a review concerning wine as a

food and medicine. Among the topics covered are the action of wine on the digestive organs, respiratory system, cardiovascular system, the kidneys, and the neuromuscular system. Chapters are also devoted to the use of wine in infectious diseases, diabetes mellitus, and as a vehicle for medication. The volume should be interesting reading for physicians and nutritionists.

ROBERT VAN REEN

## BIOPHYSICS AND GENERAL PHYSIOLOGY

INTRODUCTION TO THERMODYNAMICS OF IRREVERSIBLE PROCESSES.

*By I. Prigogine. Charles C Thomas, Springfield.* $4.75. ix + 115 pp. 1955.

In the opinion of this reviewer this book is destined to become as popular among non-experts in the field of thermodynamics of irreversible processes as K. G. Denbigh's little monograph on the same subject. The book introduces the reader to the most recent advances in the thermodynamic theory of irreversible processes, and provides a number of instructive examples of applications of the theory. The clear and concise treatment make the book ideally suited for the biophysicist or biochemist interested in examining biological phenomena in the light of the theory of irreversible processes. By including in the first 2 chapters a presentation of the results of classical thermodynamics which have a bearing on the subject, the author attempts to produce a self-contained text. There follows an excellent chapter on various aspects of entropy production including a discussion of entropy production due to heat flow, chemical reactions and electrochemical reactions, and entropy production in open systems and in continuous systems. Chapter 4 contains general statements concerning rates and affinities, fluctuation theory, microscopic reversibility, and symmetry requirements on coupling of irreversible processes. Phenomenological laws and their domain of validity are treated in Chapter 5. The very interesting subject of the stationary non-equilibrium state is treated in Chapter 6. Of particular interest to the biophysicist here is the treatment of consecutive chemical reactions in open systems, and stationary state coupling of irreversible processes. It seems certain that the complete understanding of the biological phenomena of active transport, membrane potentials, and the coupled chemical reactions of metabolism will ultimately require a formulation in terms of the thermodynamics of irreversible processes. Prigogine's book will be an invaluable aid to those interested in attempting such a formulation.

FRANCIS D. CARLSON

PROPERTIES OF SURFACES. *Ann. N. Y. Acad. Sci., Vol. 58, Art. 6.*

*Edited by Roy Waldo Miner; consulting editor, Cecil V. King; 21 contributors. New York Academy of Sciences, New York.* $3.50 (paper). Pp. 721–970; ill. 1954.

This volume consists of a group of 15 papers on the physics and chemistry of surfaces. Much of the work is concerned with metal surfaces. A paper by R. J. Archer and V. K. LaMer on The Effect of Monolayers on the Rate of Evaporation of Water should be of interest to biologists for its relevance to the interpretation of vapor pressure studies in biological systems. Other papers review the nature of bondings in adsorption, the kinetics of surface properties, the topological properties of surfaces deduced from electron emission patterns, and the adsorption of dyes to silver halide crystals.

EVELYN HOWARD

ION TRANSPORT ACROSS MEMBRANES, *Incorporating Papers Presented at a Symposium Held at the College of Physicians & Surgeons, Columbia University, October, 1953.*

*Edited by Hans T. Clarke; associate editor, David Nachmansohn. Academic Press, New York.* $7.50. xii + 298 pp.; ill. 1954.

This book is a collection of papers based on the Symposium on the Role of Proteins in Ion Transport Across Membranes held at the College of Physicians and Surgeons, Columbia University, in October, 1953 under the sponsorship of the National Science Foundation. It includes the 8 papers presented at the original symposium by Drs. Ussing, Wilson, Eyring, Kirkwood, Scatchard, Debye, Sollner, and Edsall, together with 6 invited articles by A. F. Huxley; Terrell L. Hill; Frank Gurd; Gilbert Mudge; A. K. Parpart and J. F. Huffman; and F. L. Friess, J. J. Blum, and M. F. Morales. Various aspects of ion transport in biological systems are treated in the first 6 articles. Ussing describes active and passive transport across biological membranes with particular attention paid to the active transport of sodium ions. Huxley presents a brief and excellent review of the electrical processes accompanying impulse conduction in nerves. A detailed review of energy transformations associated with conduction and a description of a possible role of acetylcholine in the metabolic pathways of the nerve cell are given by Wilson and Nachmansohn. The paper of Friess, Blum, and Morales is a brief report of some light-scattering studies on the interaction of acetylcholinesterase and its substrates. Parpart and Huffman discuss the ion permeability of the red cell with special reference to the accumulation of potassium ions. Renal mechanisms of ion transport are presented by Mudge. The 8 remaining papers deal with various theoretical and experimental aspects of the transport of ions across mem-

branes and the interaction of ions with proteins. Scatchard, Kirkwood, and Eyring discuss in their articles aspects of the problem of ion transport in terms of thermodynamics, irreversible thermodynamics, and reaction rate theory respectively. Sollner et al. report the results of their studies on model membranes. The interaction of proteins with ions and metals is treated by Edsall and by Gurd. Hill presents his theory of protein solutions and Debye treats the effect of inhomogeneous electric fields on concentration distributions in uncharged polymer solutions. The collection under one cover of the salient facts and the current concepts of ion transport across biological and synthetic membranes, together with authoritative accounts of modern theories of membrane phenomena and protein solutions, serves to make this book an invaluable reference for the advanced student and the research worker in the field.

FRANCIS D. CARLSON

RADIOBIOLOGY SYMPOSIUM *1954. Proceedings of the Symposium held at Liège, Aug.–Sept., 1954.*

*By Z. M. Bacq and Peter Alexander. Academic Press, New York; Butterworths Scientific Publications, London.* $9.80. xx + 362 pp.; ill. 1955.

The second radiobiology symposium of an international character was held in Liège in 1954, and the 50 papers, with their edited discussions, are grouped together into this symposium volume. Unfortunately, the papers presented at the Aarhus, Denmark, meetings in 1953 have never been published in collected form. Most of the Liège papers are in English; the remainder are in French. A presentation of the detailed discussion which followed the papers is manifestly impossible in such a volume, but from the diversity of subject matter it is apparent that radiobiological research has lost none of the momentum which it gained shortly after the end of the last war. If anything, the pace is faster and the breadth greater, for its influence is reaching into many experimental fields of biology, chemistry, and medicine.

A good deal of the symposium time appears to have been given to radiation protection, radiochemistry and the oxygen effect, and the physiology of irradiated systems. These are the most rapidly moving areas of radiobiological research at the present time, for it has become evident that the earlier physical interpretation of radiation effects is far too restrictive to encompass the diverse changes and relationships which have been observed. Quite apart, however, from the inherent value of the papers as up-to-date progress reports, American workers will welcome the volume because it brings to their attention the truly excellent studies being conducted by their European colleagues.

C. P. SWANSON

FUNDAMENTALS OF RADIOBIOLOGY.

*By Z. M. Bacq and Peter Alexander. Academic Press, New York; Butterworths Scientific Publications, London.* $6.50. xii + 389 pp. + 14 pl.; text ill. 1955.

PRINCIPES DE RADIOBIOLOGIE.

*By Z. M. Bacq and Peter Alexander; preface by L. H. Gray. Masson & Cie., Paris.* 4,250 fr. (paper). xvi + 478 pp. + 8 pl.; text ill. 1955.

The early genetic studies of Muller and Stadler on the biological effects of radiation, and the later studies of Sax in *Tradescantia* and of Bauer, Demerec, and Kaufmann in *Drosophila* were enormously expanded during the last war under the aegis of the Manhattan Project. These studies remained classified for the most part until long after the cessation of hostilities, but research both in this country and abroad was accelerated in the universities as well as the various atomic energy establishments. By 1946 the late D. E. Lea had published his volume which so succinctly summarized and unified the current data and ideas. The picture at that time was one based largely on physical interpretations, with the target theory occupying a central spot. By 1953, however, the picture had been reworked, for as L. H. Gray has remarked, the data made very good sense when viewed from the point of view of radiochemistry. The target theory, although preserved by some, was now so distorted as to be almost unrecognizable, but the physical considerations of Lea were not made obsolete. They were merely supplemented by the radiochemical data, and it was possible to state that at least two stages of events—the physical absorption and dispersion of energy and the radiochemical reactions of decomposed water—intervened before observable effects were noted in living cells. A third stage can now be added, a stage that is physiological and that apparently involves both the oxidative and phosphorylative aspects of intracellular metabolism. An up-to-date summary of the radiobiological field—no easy task when one considers the enormous literature that has accumulated in the last decade—must therefore take cognizance of the contributions from genetics, cytology, cell physiology, and biochemistry, and weave these together with the physical and radiochemical data.

Bacq and Alexander are well prepared to attempt such an undertaking, for both of them have been involved in research which has extended our knowledge of the chemical and physiological action of radiation as well as the protective measures which can be taken to reduce radiation damage. The result is most commendable. The book is readable, well documented, and as fairly presented as a broad, intricate, and controversial subject can be. As L. H. Gray points out in the Foreword, a comparison with Lea's book reveals remarkably few steps in the development of radio-

biology that have had to be retraced; it is an area of study where progress has been consistent and steady. It is also an area that has been greatly broadened, for the discoveries have had implications in almost all fields of science except the purely descriptive.

The coverage of this volume is not all-inclusive. To make it so would be an impossible task, and indeed an unnecessary one since the McGraw-Hill series in this field is now available. If *Fundamentals of Radiobiology* can be said to have a particular tone it is a chemical one, and understandably so, since the two authors have themselves exerted a good deal of influence in the areas of radiochemistry and radiation protection. Cytological, genetical, microbiological, and radiation sickness aspects of radiobiology are briefly but adequately treated. The effects of ultraviolet radiation are largely neglected. The authors have not hesitated to express their own particular points of view where controversy exists; they have, however, been generous with those with whom they disagree. One may well argue differently as to the significance of this or that piece of evidence, or arrive at conclusions other than those put forward, but in total aspect one must commend the authors for their presentation of a convincing and fascinating story of what has been done, as well as of what still remains to be done, in the field of radiobiology. The volume does not supplant Lea's book, but it very nicely complements it.

As indicated above, the same text is also available in a French paper-bound edition.

C. P. SWANSON

## BIOCHEMISTRY

FORTSCHRITTE DER CHEMIE ORGANISCHER NATURSTOFFE. *Vol. Twelve.*

*Edited by L. Zechmeister. Springer Verlag, Wien.* $19.80. x + 550 pp.; ill. 1955.

This volume is one of the best of this valuable series of progress reports. Its first four articles deal with the terpenes and their derivatives, the sterols and carotenoids. The amazing wealth of structures in the series of sesquiterpenes and diterpenes is demonstrated impressively by A. J. Haagen-Smit. E. R. H. Jones and T. G. Halsall discuss the tetracyclic triterpenes, particularly lanosterol, a trimethylsterol which occurs in the old "isocholesterol" fraction of wool fat and which is probably a precursor of cholesterol. The biosynthesis of the sterols is discussed by R. Tschesche, the formation of fungal carotenoids from their colorless precursors, the phytoenes and phytofluenes, by F. T. Haxo. The subject of a review by F. L. Warren is the chemistry and biological action of the senecio alkaloids which cause liver cirrhosis in cattle. J. Roche and R. Michel discuss the properties of iodinated tyrosine, histidine, and thyronine derivatives, their quantitative distribution, and also the properties of thyroglobulin and of the iodoproteins which occur in corals and sponges. The chemistry and action of snake venoms is reviewed by K. Slotta; the author, who has isolated some of these venoms, discusses their actions as esterase, hyaluronidase, protease, and oxidase. A review of the structure and action of the gene, written by G. W. Beadle, is the continuation of a similar report in Vol. 5 of this series. In addition to all these reviews, the volume also contains an article on the paper chromatography of amino acids and peptides. This critical report, written by E. O. P. and A. R. Thompson, is one of the best and most instructive articles to appear on paper chromatography; it will be invaluable to workers in this field. All of the reviews of this volume contain long lists of references and a wealth of material from widely scattered sources. I recommend the volume highly to biochemists and workers in neighboring fields.

FELIX HAUROWITZ

THE HARVEY LECTURES *Delivered under the Auspices of The Harvey Society of New York 1953–1954 under the Patronage of The New York Academy of Medicine. Series XLIX.*

*By Claude Fromageot, Hans H. Weber, David Nachmansohn, Paul Klemperer, Rollin D. Hotchkiss, Britton Chance, Albert L. Lehninger, Linus Pauling, and James D. Hardy. Academic Press, New York.* $7.50. x + 299 pp. + 1 pl.; text ill. 1955.

The high standards of the Harvey Society are upheld by this series of lectures, which includes: The Metabolism of Sulfur (C. Fromageot); ATP and Motility of Living Systems (H. H. Weber); Metabolism and Function of the Nerve Cell (D. Nachmansohn); The Intermediate Substances of Connective Tissue in Human Disease (P. Klemperer); The Genetic Chemistry of Pneumococcal Transformations (R. D. Hotchkiss); Enzymes in Action in Living Cells (B. Chance); Oxidative Phosphorylation (A. Lehninger); Abnormality of Hemoglobin Molecules in Hereditary Hemolytic Anemias (L. Pauling); and Physiological Temperature Regulation (J. D. Hardy). The long delay between the delivery of the lectures in 1953–54, and their publication in 1955, when viewed in the light of our technological ability, will probably be very intriguing to future students of our cultural attitudes.

EVELYN HOWARD

METHODS IN ENZYMOLOGY. *Volume I.*

*Edited by Sidney P. Colowick and Nathan O. Kaplan.*

*Academic Press, New York.* $18.00. xxvi + 835 pp.; ill. 1955.

The present volume is the first of a 4-volume series covering in precise detail current methods in the field of enzymology. If the subsequent volumes are as well prepared as the first, this set as a whole will be a welcome addition to our methodological literature, and will prove as indispensable to investigators in diverse fields as *Organic Syntheses* has been.

Biology at the present time is entering an era in which enzyme studies are a "must" for an increasing number of investigators. Enzymology, however, has been clothed in a mantle of holiness. The present volume is thus timely. Current methods in this field are so clearly described that no one need hesitate to tackle enzymological problems because of the reluctance of an amateur to enter the unknown. These volumes will bring the field within the reach of all.

Enzymes can be studied as enzymes of whole cells, as enzymes of a particulate cellular component, and as enzymes in crude or purified solution. Thus, the initial section of this volume is properly devoted to general preparative procedures. This section is excellent. The material covered is comprehensive in that methods are given for the use of all types of biological material, plant, animal, or microbial. Furthermore, methods are given for the preparation and use of tissue slices and homogenates, and for the preparation of particulate components and soluble systems. Enzyme fractionation is well described, and succinct accounts of the most modern techniques are given.

The remainder of this volume consists of concise descriptions of the methods involved in the preparation and determination of the enzymes of carbohydrate metabolism, of lipid metabolism, and of the citric acid cycle. The methods given in these sections are good and up to date, as in each instance an investigator currently familiar with the enzyme in question was elected to prepare the description.

Thus, this volume represents the combined experimental wisdom of a large number of biochemists and as such is an invaluable handbook for all who are interested in working with enzymes.

DAVID M. BONNER

METHODS OF BIOCHEMICAL ANALYSIS. *Volume II. Edited by David Glick. Interscience Publishers, New York and London.* vi + 470 pp.; ill. 1955.

Our complimentary comments about Volume I in this series (*Q.R.B.*, 30: 309. 1955) are equally applicable to this latest volume, which supplements the list of topics covered earlier.

Its chapters include methods for the measurement of steroids by infrared spectroscopy (H. Rosenkrantz), adrenaline and noradrenaline by chemical means (H. Persky), Vitamin E (R. W. Lehman), CoA (G. D. Novelli), Glutathione (J. W. Patterson and A. Lazarow), and serum glycoproteins (R. J. Winzler), all in biological systems. A chapter including a comprehensive discussion of total lipide analysis (W. M. Sperry), but excluding any consideration of the determination of individual lipids, is rather ambiguously titled Lipide Analysis.

Enzyme assays covered in this volume include those for proteolytic enzymes (N. C. Davis and E. L. Smith), lipoxidase (R. T. Holman), and cytochrome c oxidase by spectrophotometric means (Lucile Smith). Other chapters deal with the assay of compounds showing folic acid activity (T. H. Jukes), color reactions for the determination of sugars in polysaccharides (Z. Dische), and techniques in terminal sequence studies in peptides and proteins (H. Fraenkel-Conrat, J. I. Harris, and A. L. Levy).

There is no overlapping of material or repetition of topics. Where methods described in the earlier volume apply, cross-references to Volume I are provided (e.g., Glutathione (II) and SH determinations (I)).

*Methods of Biochemical Analysis* has the distinction of being not only authoritative, but personal as well. Of the varied methods described in the literature for the analysis of any particular biochemical compound or group of compounds, each contributor to this series has selected for detailed description those techniques which, at least by implication, carry his or her personal endorsement.

CLAUDE F. BAXTER

THE NUCLEIC ACIDS. *Chemistry and Biology. Volume I. Edited by Erwin Chargaff and J. N. Davidson. Academic Press, New York.* $16.80. xiv + 692 pp. + 2 folded charts; ill. 1955.

THE NUCLEIC ACIDS. *Chemistry and Biology. Volume II. Edited by Erwin Chargaff and J. N. Davidson. Academic Press, New York.* $14.50. xii + 576 pp.; ill. 1955.

This review, in two volumes, should satisfy the needs of the various disciplines of biology and chemistry concerned with the study of nucleic acids. The first volume and much of the second cover essentially all of the techniques involved in the isolation, identification, preparation, and properties of nucleic acids and their derivatives.

The individual sections are authoritatively reviewed, and, particularly in sections covering techniques, provide the salient practical and theoretical considerations for investigative work. The sections devoted to the composition of nucleic acids and their derivatives are presented, whenever possible, in tabular form providing easy reference for the seemingly ubiquitous nature of this type of data in the literature. The sections

covering nucleic acid metabolism and biology suffer, perhaps as most reviews of this type, from the obsolescent nature of scientific publishing in a field which has received so much attention. These latter sections, however, will provide a firm foundation for the investigator just entering this field of research.

These volumes are highly recommended to the novice as well as the established nucleic acid investigator as a "bible" for the scientific book shelf.

LAWRENCE GROSSMAN

PHARMACODYNAMIE BIOCHEMIQUE.

*By Z. M. Bacq, J. Cheymol, M. J. Dallemagne, R. Hazard, J. La Barre, J.-J. Reuse, and M. Welsch; with the collaboration of R. Crismer, S. Lapière, and R. Weekers. Masson & Cie., Paris.* 6,000 fr. (paper); 6,600 fr. (cloth). xx + 1008 pp.; ill. 1954.

The increasingly important role of biochemical knowledge in clinical medicine is bringing about a significant reorientation of teaching in certain areas of the medical curriculum. At one time essentially ancillary to physiology and rooted in empiricism, pharmacology has become invested with a secure foundation in chemistry with the development of chemotherapeutics. At first, the effects of specific substances on the host-parasite complex or on the diseased subject were investigated. More recently, the emphasis has focused on particular organs or indeed on cellular levels of organization. Currently, there are sought the effects of specific chemical substances on specific reactions, enzymatically catalyzed or not, and on specific chemical targets. Such a shift of emphasis and of content requires a close integration of biochemistry with pharmacology. A measure of this integration is provided by Bacq and his collaborators in this volume, which has been written primarily for medical students and physicians.

There are two major sections. In the first and shorter section are succinct and clear discussions of such topics as dose-effect relationships, elementary statistics, the physiology of the smaller blood vessels, permeability, enzyme kinetics and enzyme inhibition, structure-function relationships of specific agents, and excretion and transport mechanisms. The second section covers the conventional topics of pharmacology but always with emphasis on the biochemical basis and on the physiological events. The presentations are excellent; there are examples of experimental data and the illustrations are adequate. Current concepts of mechanisms are examined critically. The chapters on war gases and on substances reacting with sulfhydryl groups reflect the contributions made by the authors to these fields. Most of the text is quite up to date; there are many references but these are mostly to review articles.

There is considerably less emphasis on "anti-hypertensive" drugs than would be expected in an American work (possibly a reflection of the lesser clinical importance of hypertension in Belgium and France). Quaternary ammonium salts are unfortunately represented with quinquevalent nitrogen atoms. Authors' names are cited in the text without appropriate references being given in the bibliographies. These are minor points.

On the whole, the authors have produced a highly satisfactory and readable text which should be of interest not only to its intended readers—physicians and medical students—but also to biochemists, pharmacologists, and biologists in general.

F. P. CHINARD

RADIOISOTOPES IN BIOLOGY AND AGRICULTURE. *Principles and Practice.*

*By C. L. Comar. McGraw-Hill Book Company, New York, Toronto, and London.* $9.00. xiv + 481 pp.; ill. 1955.

*Radioisotopes in Biology and Agriculture—Principles and Practice*, by C. L. Comar, is an excellent introduction to the field of radioisotope techniques. The book is written entirely for the scientist competent in one area of biology who feels the need to use radioactive tracers, but has absolutely no experience or background in their use. The principles given are restricted entirely to those needed for understanding the techniques to be used. They are clearly stated, with a minimal use of mathematics; this is probably offensive to those with sufficient training in physics or mathematics, but serves the very useful function of getting the practicing biologist acquainted with the relevant concepts. The practice of radioisotopes is also presented clearly, and here in great detail. Throughout, the emphasis is on the non-complex nature of each of the necessary operations, on pointing out that although many precautions are necessary, there is nothing inordinately mysterious or difficult about applying them. The whole attitude is one of "come on in, the water's fine (and swimming really isn't very hard at all)."

The book starts with principles of the use of tracers, and includes a very important chapter on basic difficulties in methodology—i.e., pitfalls in experimentation and interpretation for the inexperienced worker to look out for. Radiation protection is discussed in another chapter, and details are given for handling biological materials of various sorts and radioactive tracers simultaneously. The general details of radioactive assay are presented, and the largest single chapter in the book is a compilation of the properties and procedures for all the individual isotopes. Several chapters are devoted to auxiliary techniques in isotope studies: autoradiography, paper chromatography, and ion ex-

change. In all, a very practical guide to a fruitful field. It should be a great help in getting an inexperienced biologist to take the plunge into a new technique.

A. T. JAGENDORF

CHEMICAL PATHWAYS OF METABOLISM. *Volumes I, II. Edited by David M. Greenberg. Academic Press, New York.* (I) $11.00. xii + 460 pp.; ill. (II) $9.50. x + 384 pp.; ill. 1954.

In the review of this work already published (*Q. R. B.*, 30: 82. 1955) the price of Volume II was regrettably omitted. It was also erroneously inferred that these volumes are the first of a series; instead of being, as they are, the complete treatise.

## MICROBIOLOGY

THE LIFE OF BACTERIA. *Their Growth, Metabolism, and Relationships.*

*By Kenneth V. Thimann. The Macmillan Company, New York.* $13.50. xviii + 775 pp.; ill. 1955.

Thimann has amply demonstrated his acumen and ability in the wide field of biology by providing a refreshingly new approach to the discussion of bacteria. Missing are all the clichés encountered in most texts of general bacteriology. Even the great majority of illustrations are new. In contrast to many books in the several areas of bacteriology, Thimann has emphasized the bacteria as such, without favoring cytology, metabolism, friends, or foes.

An entertaining, even fascinating, style is maintained throughout the text. Fresh considerations of the relationships of the eubacteria to other groups of microorganisms abound, not only in the chapter labelled The Bacterial Cell and its Relationship to Other Organisms, but also through all sections including cytology, the nitrogen cycle, oxidations and fermentations, and growth. For example, the discussion of lactic fermentation includes *Rhizopus*, yeasts, water molds, and *Geotrichum*, as well as the lactic acid bacteria. The chapter on the lactic fermentation includes sections on mechanism, thermodynamic considerations, taxonomic history, and the physiological characteristics of the organisms which form lactic acid.

The eubacteria are grouped along lines of activity rather than strict taxonomy; this approach results in comparisons which will be more easily understood and assimilated by the student. From the general tone of the text, it may be concluded that the author, in company with many others, is not entirely satisfied with the taxonomic situation of the bacteria.

Thimann has tilted with many of the windmills in bacteriological history. For example, the "true" author of "Koch's postulates" is revealed, and many of the favorite "discoverers" are not present in this volume although their discoveries are discussed. It is obvious that earlier texts were not used as source material.

On the red side of the ledger, it is not likely that Thimann will find a great number of subscribers to the conclusion that "the whole propionic fermentation can now be formulated." This reviewer takes exception to the continued use of the term "fermentation" when applied to oxidations in which oxygen acts as the hydrogen acceptor, even when such usage is rationalized.

Since the book presumably was written largely for a domestic market, it is, as the author predicts, somewhat surprising to find such marked departure from the taxonomic positions and genus abbreviations which are generally accepted in this country. This is not to say that the author's intentions in this regard are wrong or even isolated, but in view of the lack of a ready and complete reference work on which to base his system of nomenclature, it would seem better from the student's standpoint to retain the system which is already in use.

In general, and in spite of the occasional ambiguities and disagreements, which are to be encountered in any textbook, this volume is well recommended as a general bacteriology text, primarily because of its non-standard biological and comparative approach to the subject.

R. D. DEMOSS

MICROBIOLOGY. *An Introduction.*

*By Ernest Gray. Philosophical Library, New York.* $3.75. xii + 175 pp.; ill. 1955.

This little book is intended to be a simple introduction to microbiology at a lower undergraduate or technicans' level. It has the admirable aim of unifying the study of bacteria with that of other microorganisms ("organisms so small that a microscope is needed to make out their structure" being, however, too facile a definition), that is, molds, algae, and protozoa. It is written in a direct style, and books of this genre are clearly needed. These virtues are, however, gained at too great a cost. The historical view which is aimed at too often turns out to be folklore and unauthenticated tradition; unfortunately, the same is too often true of the scientific assertions. Clear writing is easy when it expresses dogmatisms, and when these are undocumented, they are too often wrong. Such statements as "The thermal death point is the lowest temperature above the maximum for growth which will kill a bacterium instantly" and "The mycelium of a mould is a loose one, and thus they can be distinguished from those fungi whose hyphae form dense fleshy tissues, such as the mushroom" are so prevalent as to impair the reliability of the text as a source of information for uninformed readers.

JOSHUA LEDERBERG

A MANUAL OF MEDICAL VIROLOGY.

*By S. S. Kalter and J. E. Prier. Burgess Publishing Company, Minneapolis.* $3.50 (spiral-bound paper). iv + 127 pp.; ill. 1955.

This manual is designed for medical students as an introduction to virology. The laboratory exercises included are relatively few, but they are designed to acquaint the student with the various techniques used in the cultivation and identification of viruses. The exercises comprise only one-third of the manual, the remainder being devoted to a concisely summarized survey of what is known about the medically important viral and rickettsial diseases. The excellent schematic representations of methods for inoculating and harvesting virus in animals and chick embryos, and of the use of tissue culture methods, should prove useful to the student. There are, as in most manuals, certain minor inadequacies, such as the use of incomplete references giving only author and date, the employment of the 100 per cent rather than the 50 per cent endpoint in the *titration* of complement, and the inaccurate use of serial rather than parallel dilutions. On the whole, however, the manual fulfills its purpose and should be useful in the teaching of virology to medical students.

MORTON M. WEBER

QUANTITATIVE BACTERIAL PHYSIOLOGY. *Laboratory Experiments.*

*By Michael J. Pelczar, Jr., P. Arne Hansen, and Walter A. Konetzka. Burgess Publishing Company, Minneapolis.* $2.75 (spiral-bound paper). x + 150 pp.; ill. 1955.

This well-conceived manual is designed for use in an advanced undergraduate or elementary graduate course in microbial physiology. The authors do not attempt to cover the entire field, but rather to acquaint the student with some of the quantitative techniques used in the study of bacterial physiology. The contents consist of exercises on the following topics: colorimetry and nephelometry, bacterial growth determinations and nutritive requirements, microbiological assay, the preparation of cells and cell-free extracts, methods for determining enzymatic activity, genetic aspects of microorganisms, and fermentation analyses. Most of the exercises are well planned, although a quantitative recovery experiment is lacking in the section on microbiological assay. In addition, with the recent introduction of spectrophotometric techniques in the measurement of enzymatic activity, an experiment utilizing this tool should have been included.

On the whole, however, this manual is highly recommended as a useful adjunct to the laboratory instruction of bacterial physiology.

MORTON M. WEBER

LABORATORY INSTRUCTIONS IN MICROBIOLOGY.

*By Louis P. Gebhardt and Dean A. Anderson. The C. V. Mosby Company, St. Louis.* $3.25 (paper). 253 pp. 1954.

The authors have been successful in compiling a general microbiological laboratory manual in which a simple, instructive, and stimulating experiment is included for practically every major topic in the field. The manual consists of laboratory exercises on the following general topics: basic principles and techniques, physiological activities of microorganisms, the effect of physical and chemical agents on microorganisms, sanitary microbiology, soil microorganisms, and pathogenic microbiology. Included also is a useful appendix consisting of the descriptions of culture media preparation and of staining techniques and reagents.

This excellent manual is highly recommended for use in an introductory course in general microbiology.

MORTON M. WEBER

## PARASITOLOGY

INTRODUCTION TO PARASITOLOGY, *with Special Reference to the Parasites of Man. 9th Edition.*

*By Asa C. Chandler. John Wiley & Sons, New York; Chapman & Hall, London.* $8.50. xiv + 799 pp. 1955.

The 9th edition of this book, like the preceding editions (8th ed., *Q.R.B.*, 26: 228. 1951), is the most readable text in its field. Among the books available, it is the nearest approach to a general parasitological text for collegiate and university courses. Although it deals primarily with those parasites which afflict man, it is not, and does not pose as, a medical book. Nevertheless, the medical student and the practicing physician, the graduate student and the professional parasitologist, and the public health workers, as well as the collegiate student, will find that the book contains much valuable information.

The introductory sections, Preface, Chapter 1 (Introduction, pp. 1–12), and Chapter 2 (Parasites in General, pp. 13–30), are short but effectively written and give the student an insight into the biological principles and problems involved in parasitism, without bogging him down in a mass of details. No one, least of all the author himself, would contend that the various ramifications of the host-parasite relationships had been completely evaluated in the brief accounts on Resistance and Immunity and on Host Specificity. The reader is merely shown the principles involved and put in contact with the original literature on the subject.

In common with other texts in parasitology, the principal subject matter is presented under three main divisions: Protozoa (pp. 31–226), Helminthology (pp.

239–499), and Arthropods (pp. 500–770). Although the spirochetes are generally regarded as bacteria, they are included, as exlained in the Preface, since they "... are given inadequate treatment in bacteriology books and are repeatedly referred to in this book in connection with their arthropod vectors...." Similarly, because some of the bacteria, rickettsias, and filtrable viruses are arthropod-transmitted, they are described in part of a chapter on the Protozoa under the heading Arthropod-Borne Organisms Other than Protozoa. Taxonomic and morphological details are largely omitted. The nomenclature is up to date and appears to be accurate throughout, but the taxonomist may be disturbed by the absence of synonyms, particularly the omission of generic and specific names which have been long in use and but recently discarded or assigned to amended usage. In place of morphological minutiae, this book refers more to the biological subtleties involved in parasitism.

Those major groups with no parasites in man are reviewed at least briefly. Most of the parasites which are of serious concern in the health of domesticated animals are at least mentioned. It is, however, in this area that the reviewer found his only real disappointment. The recurrent emphasis here upon their rare accidental occurrence in man, while numerically correct, tends to deviate the student's attention from the greater significance of these organisms as biological entities and, in some instances, as pathogens of animals. An extreme example of this unbalanced emphasis is the statement on p. 487 concerning *Protospirura muricola*: "Though not yet recorded from man, this rodent parasite . . ." *etc.*

In spite of this one minor adverse criticism, the author and the publisher are to be congratulated on again producing a useful and effective text in parasitology, useful to all groups interested in the subject, but particularly effective for university and collegiate courses.

GILBERT F. OTTO

## HEALTH AND DISEASE

ANTIMETABOLITES AND CANCER. *A Symposium Presented on December 28–29, 1953, at the Boston Meeting of the American Association for the Advancement of Science, Washington.*

*Edited by Cornelius P. Rhoads. American Association for the Advancement of Science, Washington.* $5.75; (AAAS members, $5.00). vi + 312 pp.; ill. 1955.

The holding of this symposium, and the publication of the papers presented at it, are sufficient evidence that an attack on the cancer problem through the use of specific antimetabolites is not a visionary's dream but a practical approach which continues to offer hope of ultimate success. Since encouraging results have been forthcoming despite the empirical procedures which must be employed in this type of research, it is not surprising that the attack has been pressed vigorously from many sides. This volume is therefore a measure of the intensity of the attack, a summing up of current progress, and, as a reading of the 18 papers indicates, a guidepost and a promise to the future.

Seventeen of the papers deal with specific problems being studied, and cover the metabolic action of a wide variety of substances which offer some hope of specifically interfering with the growth and spread of neoplasms. There is a general note of optimism which runs through each presentation, tempered however by the uncertainty in many instances of knowing whether the metabolic pathways of normal and neoplastic cells are essentially different, or whether the differences noted are only quantitative. The major emphasis is on antagonists of nucleic acid and hormones. The last paper is by the editor, C. P. Rhoads, and is titled: The Seeing Eye of Science. In it he points to the popular fallacy that, given the total picture of the problem at hand, a practical solution is inevitable, e.g., because we made an A-bomb with two billion dollars, we can lick the cancer problem if we have enough money. Unfortunately for the subscribing public which supports a good deal of cancer research, basic problems cannot be solved in such predictable fashion, and more often than not it is the dedicated scientist, playing an inspired hunch or arriving at a clever deduction, who has opened a door when the way seemed solidly barred. The cancer problem will possibly yield to such a solution in piecemeal fashion, but until it does humanity demands that we pick the lock of every door that blocks progress. The approach through the use of antimetabolites may be mere lock-picking, but one dares not neglect it.

C. P. SWANSON

K*. * *Krebiozen—Key to Cancer?*

*By Herbert Bailey. Hermitage House, New York.* $3.50. viii + 312 pp. 1955.

In the early 1950's a great and bitter discussion arose in medical circles over Krebiozen, a new drug discovered by Steven Durovic, a Yugoslav refugee physician, and tested out on cancer patients by Andrew C. Ivy, one of the world's foremost scientists, and many others. The disagreement between the Krebiozen researchers and their antagonists became so strong that the Legislature of the State of Illinois made an investigation. Other investigations were instituted.

Ivy, who had been severely criticized and suspended from the Chicago Medical Society for three months and later not re-elected as Vice President of the University of Illinois, told the author, Herbert Bailey, a veteran newspaper reporter, that "the truth must be

told to the medical profession. I don't want this incredible thing that has happened to me, to Dr. Durovic and to any other honest research effort to ever happen again in science. That must not be. It cannot be."

This book is written so that the lay public may read the details of the controversy. It also contains descriptions of the biological and medical principles underlying the development and clinical experimentation of Krebiozen, which will make the volume of great interest to the scientific reader.

The story of the bitter controversy is traced through the months and years and is substantiated by generous quotations and affidavits, which lend authenticity. The author describes vividly and enthusiastically the contributions of Durovic and Ivy. Many factual data are presented. At times the author criticizes rather strongly the antagonists to Krebiozen and the conventional researches in a manner which tends to weaken some of his arguments.

Ivy is quoted as saying, "It is my opinion that the substance merits a thorough clinical study and evaluation, since I believe it shows promise in the management of the cancer patient." He (Ivy) did not claim that Krebiozen is a cure for cancer. From the data presented it is apparent that Krebiozen has merit and that further laboratory and clinical investigation is needed. The chemical structure of this substance is being studied. The U.S. Senate passed Bill 1159 to allow the Durovics to remain in the United States and continue Krebiozen experiments. Time will evaluate Krebiozen.

GRANT E. WARD

ATLAS OF EXFOLIATIVE CYTOLOGY.

*By George N. Papanicolaou. Published for The Commonwealth Fund by Harvard University Press, Cambridge.* $18.00 (loose-leaf in ring binder). xvi + 211 + xvi pp. + 36 pl. 1954.

Although the current interest in "exfoliative cytology" began with the introduction by Stockard and Papanicolaou of the vaginal smear technique for analyzing the sex cycle of the guinea pig, the procedure has gained clinical importance in the diagnosis of cancer. Stained smears of secretions into which tumor cells may have been shed are examined microscopically and an effort is made to distinguish normal cells from those that are altered in appearance because they are cancerous. Cells may undergo a variety of changes which simulate those of malignancy, however, and this can make the positive identification of the isolated cancer cell difficult. Even more serious would be the erroneous diagnosis of a cell as cancerous when in fact it represented a benign atypism. Papanicolaou's *Atlas*, with its many colored plates, should be of some help to the pathologist, but like any other tool, in the hands of the inexperienced it might lead to tragic errors.

After a chapter on technique and one on the criteria of malignancy (nuclear and cytoplasmic changes), there follow chapters on the normal, atypical, and malignant cytology of the female genital system, urinary and male genital systems, respiratory system, digestive system, exudates of serous cavities, and breast. Although this would seem to include most possible sites of cancer, it should be pointed out that in practice, cancers of the cervix and lung are the tumors in which this technique offers most help in diagnosis.

The format is that of a large loose-leaf notebook with a flexible cover. This will permit the addition of supplements as they become available. The text is illustrated by 36 plates in color. The printing of the text and the color reproductions are of good quality.

HANS G. SCHLUMBERGER

CANCER: *Race and Geography. Some Etiological, Environmental, Ethnological, Epidemiological, and Statistical Aspects in Caucasoids, Mongoloids, Negroids, and Mexicans.*

*By Paul E. Steiner. The Williams & Wilkins Company, Baltimore.* $5.00. xiv + 363 pp.; ill. 1954.

This volume is a much needed contribution to increase our understanding of the etiology of human cancer by statistical analysis of the racial and geographical differences in the occurrence of cancer. A careful study of the 20 most common lethal types of tumor seen in Caucasoids, Negroids, and Mongoloids is reported from autopsy material at the Los Angeles County Hospital as well as from these racial groups in other parts of the world. There were 35,293 necropsies suitable for analysis performed at the Hospital in the years 1918 to 1947.

This vast amount of material is presented in four steps to show: (1) that racial differences exist in some forms of cancer, but not in others; (2) that the racial differences are explained by environmental or hereditary factors by comparing migrants and their sedentary racial relatives; (3) that some tumors exhibit biological differences associated with race other than in frequency; and (4) that logical deductions are made from the observed statistical and biological data.

The carefully compiled statistical data are arranged in 50 tables and 73 lists of figures. The 20 main types of lethal tumors are discussed in separate chapters. Other less common tumors are presented in one chapter. Then there are summaries by geography and ethnic groups and concluding comments.

This book contains a large amount of information of great value in the clinical study of human cancer. It is another step in the attempt to bridge the "hiatus that has developed between clinical medicine and laboratory cancer research."

GRANT E. WARD

## PSYCHOLOGY AND ANIMAL BEHAVIOR

PROBLEMS OF CONSCIOUSNESS. *Transactions of the Fourth Conference, March 29, 30, and 31, 1953, Princeton, N. J.*

*Edited by Harold A. Abramson. The Josiah Macy, Jr. Foundation, New York.* $3.25. 177 pp.; ill. 1954.

PROBLEMS OF CONSCIOUSNESS. *Transactions of the Fifth Conference, March 22, 23, and 24, 1954, Princeton, N. J.*

*Edited by Harold A. Abramson. Sponsored by The Josiah Macy, Jr. Foundation, New York.* $3.50. 180 pp.; ill. 1955.

These 2 volumes are the last of a series of 5 annual group discussions on problems of consciousness. In earlier volumes various aspects of the physiological, psychological, and psychopathological approaches to these problems were presented and discussed. In the Fourth Conference, Roy Grinker presents a review and analysis of what has gone before, in addition to certain new suggestions. This discussion is followed by the contributions of Talcott Parsons on Consciousness and Symbolic Processes, and Jean Piaget on Developmental Changes in Awareness. The last (5th) conference is more unstructured and deals with consciousness in its relation to emotions, anxiety, and anesthetics. All these discussions will be profitable to investigators in many fields, but (as pointed out in the closing remarks of the Fifth Conference) perhaps even more so to the active participants.

The presentations are thought-provoking and most revealing in so far as they demonstrate both the meagerness of knowledge and the remarkable diversity of approach to these complex problems.

R. G. GRENELL

TIME DISTORTION IN HYPNOSIS. *An Experimental and Clinical Investigation.*

*By Linn F. Cooper and Milton H. Erickson, with a foreword by Harold Rosen. The Williams & Wilkins Company, Baltimore.* $4.00. xvi + 191 pp. 1954.

*Time Distortion in Hypnosis* is devoted primarily to the report of experimental studies rather than to theoretical discussion. The absence of theory is not surprising in view of the fact that no single theory has yet been presented that adequately explains the hypnotic state.

The volume is divided into two unequal parts. The first part consists of 23 short chapters of experimental studies in time distortion in hypnosis and a Semantic Interpretation of Verbal Suggestion, by Cooper. The second section consists of a single chapter by Erickson on clinical and therapeutic application of time distortion.

For those who are interested in the phenomena of hypnosis as well as for those who are interested in learning, Cooper has presented some stimulating material. Beginning with his first experiments on time distortion in 1948, he has restricted his definition of the term to that of a marked difference between the seeming duration and the clock reading of a given interval of time. While time distortion has been known to occur under a variety of conditions, Cooper has made it possible for the phenomena to be observed and studied under rigidly set and specifically stated conditions.

The first 7 chapters are used for introductory purposes. There is both a general and specific discussion of time. The special terms used are defined and the subjects, methods, training, and experimental bases of the report are explained. The essential task of the experiment is directed to the possibility of the sense of duration of time being altered by verbal suggestion in the trance. A task is assigned to a hypnotized subject and the relation between seeming duration and clock time is studied.

The next 14 chapters are devoted to experiments in time distortion with regard to a variety of topics including counting, association, thought, creative thinking, motor learning, non-motor learning, and polygraph studies. No one of these topics is treated exhaustively, but rather a number of pilot experiments involving different problems is presented. The last 2 chapters of Part I are given over to the Semantic Interpretation of Verbal Suggestion and experimental conclusions.

It is difficult to evaluate satisfactorily Cooper's contribution since he has indicated that he did not intend exhaustive studies of a single topic but rather pilot studies of many. The report of the experiments is so abbreviated as to prevent any possible evaluation of necessary conditions. It is evident in several of the pilot studies that Cooper has opened a question that demands the attention of learning theorists. The conclusions are indefinite and still open to criticism and more experimentation. Many readers will still question the role of retrospective falsification or elaboration despite Cooper's efforts to meet this objection both in the sections of Special Inquiry and on Semantic Interpretation. To many the experimental work will appear to stand up better without the Semantic Interpretation. Cooper appears to have indicated well the importance of time distortion, but exact conclusions must await more exhaustive study of single topics.

The final chapter, on clinical and therapeutic applications, is inconclusive, as are most therapeutic explanations.

G. WILSON SHAFFER

THE EXPRESSION OF THE EMOTIONS IN MAN AND ANIMALS.

*By Charles Darwin; preface by Margaret Mead.*

*Philosophical Library, New York.* $6.00. xii + 372 pp. + 16 pl.; text ill. 1955.

The reprinting of scientific classics which are virtually unobtainable in the second-hand market is laudable. In the present instance, however, it is not at all clear what service is rendered by issuing a $6.00 photo-offset version of a book that is obtainable in almost any large city at a price of $1.50 or $2.00. The very brief introduction by Margaret Mead and the interesting illustrations of animal expressions by Konrad Lorenz and of human expressions of emotion from photographs of the Balinese supplied by Gergory Bateson and Margaret Mead, and of American anthropologists supplied by the Louisville University Institute for Culture and Communication, are definitely not worth an extra $4.00. This book is therefore recommended only to those ethnologists and evolutionists who cannot find a good second-hand copy of one of Darwin's minor works.

BENTLEY GLASS

## HUMAN BIOLOGY

THE LANGUAGE OF SOCIAL RESEARCH. *A Reader in the Methodology of Social Research.*

*Edited by Paul F. Lazarsfeld and Morris Rosenberg. The Free Press, Glencoe, Ill.* $6.75. xiv + 590 pp.; ill. 1955.

This handbook can safely be described as very considerable, but before going on to consider it, I wish first to review briefly its contents. These are divided into 6 sections of readings, the first 5 of which are consecrated (a word chosen advisedly) to concepts and indices, multivariate analysis, the analysis of change through time, formal aspects of research on human groups, and the empirical analysis of action. The 6th and final section is entitled Toward a Philosophy of the Social Sciences. The editors have provided a general introduction to the volume, and also for each section a separate introduction which capably fits the selected readings (between 7 and 14 for each section) into the general framework of the whole. Where desirable, editorial comment accompanies the readings themselves; each section includes also a list of auxiliary readings.

Although a few of the readings have been written expressly for the purposes of this volume, most of them have been selected from other and previous publications, and those chosen are admirably suited for the illustration of the principles to which they apply. It cannot be denied, therefore, that the book as a presentation of methodology is a commendable success.

The editors, in their very thoughtful general introduction, make various defenses in favor of the development of a methodology, including one which might well be challenged in a review written by a natural scientist. This is the bald statement that "it is an undisputed historical fact that a methodological self-criticism has served a very important function at crucial phases in the development of the natural sciences." Instead of merely pointing out how silly it is to claim that any historical fact is undisputed, I shall proceed to dispute this one. Galileo admittedly said a few words about measurement, but he did so in utter unselfconsciousness. Newton, Planck, and Einstein refrained from explicitly telling people how to think. So did Willard Gibbs. William Harvey was interested primarily in the movement of the blood rather than in the method per se of its demonstration. At least he failed to stress, and probably to recognize, the significance of the new methods which he used. The line between method and material has remained so vague in the natural sciences, —to say nothing of the unnatural ones,—that it has defied being drawn incisively by even the most acute of philosophers. In fact, to some natural scientists what is most startling about the course of scientific progress is that as much understanding of nature has been acquired as has been, in the absence of any rigidly prescribed discipline of thought and action which can be succinctly formalized into general systems.

It might be maintained, of course (though it is not done in this book by these editors), that concentration on method is appropriate for a group of sciences which deal with subjects which have up to so recently been studied, if at all, only with passion or emotion. There is some weakness in this argument too. Method is only as serviceable as are the data attained by it, and the interpretations put on them, and the emotional temperature of the investigator is not always a measure of the degree to which his findings lead to new insights. Freud probably generated considerable heat in his day, one way and another, but he has had his influence, whether one cares for it or not. The test of a method lies in its ability to answer a question. It itself can hardly frame the question.

The materials into which social research inquires are notoriously difficult to cope with, but embryos, which provide the material for my own investigations, are pretty complicated, too. Postnatal individuals, with whom social scientists have to deal, at the stage at which the social scientist investigates them, are usually only one individual each,—at least, they are considered to be fair game for the psychiatrists if they have two or three personalities apiece. The embryo, in contrast, still has all the varied potentialities, which it normally is not in a position to express, of developing in many directions additional to those it customarily follows. This hardly makes it less complex to study than the adult. Furthermore, grown-ups at least sometimes are able to answer questions in words intelligible to the asker of the question. Embryos are always absolutely silent in this respect.

I cite these difficulties which arise in connection with working with embryos to make the point that there are aspects of organisms under investigation by natural science that are not necessarily simpler than those

which social science studies—and also not necessarily dissimilar to these. Embryos are not social creatures in the main and generally do not form institutions. But in spite of the fact that they contain the capacities for forming many individualities, they are unified into one (an organization of very high order, by the way, in anyone's classification), and each behaves uniquely. They, therefore, can be studied adequately only in fairly large numbers, and what experimental embryologists really study is populations of embryos.

Now one reason for my acceptance of the invitation to review this book was that I thought I might possibly find in it some hints to new methods applicable to the study of the embryo, and such section headings as The Empirical Analysis of Action, Multivariate Analysis, and especially The Analysis of Change Through Time encouraged me in my hopes. Reading the text disabused me of my optimism. At least some of the procedures practiced in the method that is formalized as multivariate analysis have been in common usage, whether or not mathematically justified, by experimental embryologists who found some time ago that there was no more satisfactory way to analyze, or better, to describe, the relationships of a multiplicity of cooperating factors, and who have gone about their work without troubling to label an arrangement of little boxes "a four-dimensional attribute space laid out in two dimensions," (and who, it might also be mentioned, manage to publish graphic illustrations which are at least comprehensible as to screening and legible as to lettering, which is more than can be said for some of the figures in the present volume, cf. pp. 144, 196–97).

It is with respect, however, (and very great respect, for it is very humbling) to the problem of analysis of change through time that the embryologists have the greatest stake in the outcome of the analyses carried out by the practitioners of social research. Many of us who were fortunate enough to be bred in the laboratories of Ross Harrison appreciate the value of what he taught us, namely, that studying the physiology of developing embryos is not the same thing as studying the physiology of development itself. And some of us, like myself, keep harping on the fact that one reason for this is that the techniques applicable to the former do not suffice for the latter. But even those of us who, including myself, labor this point in writing probably too often (even in reviews of books on social research) are thoroughly cognizant of the fact that talking about the need for a new technique is largely idle, since its invention awaits the formulation of a new Fragestellung in reference to the embryo, and we know that the clue to how to frame our new question can come only from studying the embryo itself and not from generalizing about method.

The section in this reader on the analysis of change through time does not suggest that the investigator in the field of social research is any closer than the embryologist to an analysis of the development implied in change. The trend, panel analysis, and prediction studies indicate that change occurs, and relate to change some factors that may be instrumental in producing it. They do not yet, any more than do the investigations of the embryologists, probe to the essential nature of the process of change that they describe.

Since the embryologist confesses himself thoroughly baffled by the same fundamental problem, the criticisms expressed in these remarks are more sympathetic than they may perhaps sound at first ring. Indeed, it is only because I feel myself in a way an insider who can estimate the difficulties inherent in the problems at hand that I permit myself the candor with which I express my views. It cannot be emphasized often enough that in dealing with such complex matters as those under discussion here, descriptive studies must be carried out, by as accurate procedures as possible, before true analyses can be carried out at the depth that leads to synthesis. From this point of view, the value of the work currently being carried out in social research is not to be minimized. In addition, it is all to the good that the social scientist is performing his descriptive studies within a frame of reference that recognizes that structure and function are inseparable and that their relationship is dynamic to a high degree.

But this does not solve the crucial problem as to whether the social scientist will make greater progress by concentrating on methodology as such than by preoccupying himself with the nature of his materials. It is my opinion that far more hope is held out for the future by R. K. Merton's 20 brilliant pages on A Paradigm for the Study of the Sociology of Knowledge, which deals essentially with concepts rather than methods, than by most of the rest of the book put together.

It would be amusing to have had an analysis, pursued by the modern methods of social research, of the audience reaction to the walk of the emperor without his clothes, had his people permitted him to mingle with them. All I know, in simple and common sense terms, is that when you notice a man strolling through crowds naked, you question his motives. But when you see his clothes walking down the street, without him or anyone else inside them, you wonder a bit about your own sanity.

JANE OPPENHEIMER

OLD AGE IN THE MODERN WORLD. *Report of the Third Congress of the International Association of Gerontology, London, 1954.*

*E. & S. Livingstone, Edinburgh and London; [The Williams & Wilkins Company, Baltimore].* $8.00. viii + 647 pp.; ill. 1955.

This volume of 647 pages presents, either as full articles or brief abstracts, a large proportion of the papers read at the Third International Gerontological Congress

held in London in July 1954. The book is divided into 17 chapters ranging from Age and Society to Tissue Changes and the General Aspects of Ageing. It is true that relatively few of the papers deal with aging as a biological problem; that is, as related to species other than man or as a fundamental property of protoplasm. However, viewed in a broad perspective, the problems of social relations among humans and the methods devised to improve them are also problems of biology. In this context, there is much of biological interest in the volume.

Reports concerning the genetic aspects of aging and the factors controlling longevity in the rat are found in the final chapter of the book, General Aspects of Ageing. Chapter V, Tissue Changes, contains reports of studies on the morphological, as well as functional changes with age, as observed in various animal tissues. Metabolic and nutritional factors are reported in Chapter IV, on Nutritional Aspects of Ageing. Most of the studies on physiology appear in the chapter on Endocrinology or in chapters concerned with disease states, such as cardiovascular disease.

One may disagree with the Editorial Board's choice of chapter headings and their organization of the material, but the problem of integrating the variety of topics discussed is a formidable one. Although some of the papers appear in unexpected places, an index affords the reader an opportunity to find reports on the topics of his interest. Many of the papers are reported only as brief abstracts and might well have been omitted; the same might also be said of some of the lengthy discourses. It is strikingly evident that few general concepts with regard to the biological basis of the aging process have been formulated.

The size of the volume and the number of papers read is an index of the increasing interest in gerontology. The fact that some eighty per cent of the space is devoted to the social, economic, and clinical problems of aging man is evidence of an increasing concern with the practical problems produced by the rising tide of older people in our population. The scarcity of papers on the biological aspects of aging may be deplored, but is a reflection of the fact that few biologists have chosen this basic property of protoplasm as a research problem. This is a matter of serious concern, since the interpretation of clinical studies on man, important as they may be, must ultimately rest on a firm biological basis, namely, on a knowledge of the nature of the aging process. Biologists should read this volume not only to obtain a broad view of the important problem of aging, but also to gain an impression of the need for more fundamental studies of the process of aging which they are prepared to undertake.

N. W. Shock

## DE OMNIBUS REBUS ET QUIBUSDAM ALIIS

Research Films in Biology, Anthropology, Psychology, and Medicine.

*By Anthony R. Michaelis. Academic Press, New York.* $10.00. xvi + 490 pp.; ill. 1955.

Starting with the statement that "a research film results from the application of cinematography to the systematic search for new knowledge in the sciences," this book admirably surveys the field. In the introduction some historical background is given, then supplemented by comments on the development of suitable equipment and of techniques for planning and analyzing research films.

Part 1 (the biological sciences) considers film widths, supports for cameras, camera types, microscopes for cinematography, beam-splitters for observation while filming, time-lapse studies, and an analysis of films already made in various fields from microbiology, through locomotion studies, animal behavior, circulation and heart studies, etc., to plant research records.

Part 2 (the human sciences) concerns anthropological, psychological, and psychiatric studies for which research films have been, or can be, made. Time and motion analysis is included.

Part 3 (the medical sciences) describes and illustrates many of the special types of equipment needed for cinematography in surgical theaters, for recording features of illuminated cavities, and for use with x-rays. Consideration is given to outstanding films already prepared dealing with aspects of medicine; these are discussed an organ system at a time.

A 92-page author and reference index is followed by a very adequate subject index.

This work seems likely to remain the standard reference book for research films in the fields covered for a decade or more.

Lorus J. & Margery Milne

The Silent World.

*By J. Y. Cousteau, with Frédéric Dumas. Pocket Books, New York.* 35 cents (paper). xiv + 225 pp.; ill. 1954.

The original American edition of this book went through 10 printings, followed by various condensed and serialized versions, and now it has found its way to that familiar inflorescence of our culture, the racks of paper-bound novels (whose gaudy covers make it embarrassing to be seen looking at them at all). It is encouraging to see that the publishers are venturing more and more into this sort of thing, and *The Silent World* is a happy choice, since it is still far better than most of its imitators. The color plates are not as bright as in the more expensive editions, but they are acceptable—especially for the price.

As is well known, this book tells the story of the development in France of the apparatus now known as the aqua-lung, and the experiences of the pioneer users of this apparatus, first as researchers for the Navy, then as scientists and sportsmen, exploring caves, old wrecks, and the marine grottoes of the Mediterranean.

JOEL W. HEDGPETH

THIS IS DINOSAUR. *Echo Park Country and its Magic Rivers.*

*Edited by Wallace Stegner. Alfred A. Knopf, New York.* $5.00. viii + 97 pp. + 34 pl. 1955.

The need, real or imagined, continues unabated for more dams to conserve and redistribute our water supply. One of the present plans, conceived by the U. S. Bureau of Reclamation, proposes to construct on the Green and Yampa Rivers at the Utah-Colorado border a series of dams which, at high water, would almost totally inundate the Dinosaur National Monument and create an inland sea thousands of acres in extent. This is an area of mountains, valleys, plains, and rivers of breath-taking beauty and grandeur, and its loss under water would of course be irretrievable. The question, therefore, is whether the advantages to be gained from the impounded water would be worth the loss of this national park to the American people. This book, describing through text and photographs the scenic, recreational, and cultural values of the area, is a plea for the preservation of this unique tract of land which, according to the Act of Congress creating the National Park Service, was to be left unimpaired for future generations. After reading the book one can only hope that an alternative plan will be found to satisfy the yearning of the Bureau of Reclamation for more water, yet preserve the land where the dinosaurs once roamed.

Since the book was issued the project to erect the dams has been abandoned, at least for the time being, and Dinosaur Monument is still available to those who would enjoy its unparalleled beauties.

C. P. SWANSON

TREASURY OF PHILOSOPHY.

*Edited by Dagobert D. Runes. Philosophical Library, New York.* $15.00. xxiv + 1280 pp. 1955.

The nearly 1300 pages of this volume include excerpts from the writings of some 400 philosophers. The entire period of philosophic thought is covered, and in addition to selections from those familiar to Western minds are items from the less familiar Hebraic and Oriental philosophers. As individuals, these philosophers are a motley crew, coming from many walks of life and representing many professions; they have in common only the fact that they have set down meditative thoughts worthy of being read and pondered.

A volume of this sort, covering so wide a variety of writings, can do little except to introduce the tenor of a philosopher's thoughts, and to spark the reader to further study of each author's major works. These are listed in the short biographical sketch that precedes each selection. The book is therefore more in the nature of an elementary reference text, although its value as such is greatly reduced by the fact that there is no index other than that for authors. As a result no clue is provided to either the nature or the contents of the included selections.

SEVEN MEN AMONG THE PENGUINS. *An Antarctic Venture.*

*By Mario Marret; translated from the French by Edward Fitzgerald. Harcourt, Brace & Company, New York.* $4.50. xii + 269 pp. + 8 pl.; text ill. 1955.

Every nation which has its piece of land in the Antarctic has, in recent years, sent scientific expeditions thither, for one reason or another. Usually meteorological, oceanographic, and geological information for purposes of commerce or national security is the prime reason for these expeditions, but a byproduct has been some very excellent semipopular books on a little-known area of the globe. This is one of them. The expedition was French, and the winter of 1952 was spent at the foot of the Terra Nova Glacier in Adélie Land, the French sector of Antarctica. Excursions by dog-sled and weasel extended inland and to the northwest along the coast. M. Marret conveys with telling clarity the rigors of such a winter, along with the grandeur and fascination that the Antarctic holds for adventurous men. He also succeeds in bringing out the impact of the immense solitude on each of the seven men, and the necessity for coordinated effort to insure survival.

Part of the efforts of the French group was devoted to a study of the huge Emperor penguin. Apart from rather general comments, however, these studies are not included here but have been reserved for publication elsewhere, in professional journals. The book, despite its excellence, should be viewed as a popular rather than a scientific account of a year in the Antarctic wastes.

C. P. SWANSON

THE QUARTERLY REVIEW OF BIOLOGY publishes critical reviews of recent researches in all of the special fields of biological science. The contribution should present a synthesis or digest of the researches and a critical evaluation of them. A mere synopsis of the literature without evaluation or synthesis is not desirable.

Theoretical papers are published occasionally, especially when such papers (1) include a critical synthesis of the literature bearing on the theory and (2) are likely to promote further research in a given field.

The article should be written in concise language, yet in sufficiently non-technical form as to be intelligible not only to specialists in other fields but to the general biologist as well. To this end the article should have a general introduction and a summary which enumerates one by one all of the principal facts and conclusions given in the paper. Interpretative diagrams and schemes are very desirable.

Material ordinarily taking the form of footnotes is set in small print and placed in the text and consequently should be written in a style so as to fit readily into the text. Acknowledgments are printed in the text in small type at the end of the article just preceding the List of Literature. Recent issues of the Quarterly should be examined for style as regards (1) section or subsection headings in the text, (2) literature citations in the text, and (3) List of Literature.

The subjects and authors of articles are selected by the Editors and members of the Advisory Board. Unsolicited articles which conform with the objectives of the Quarterly will be considered for publication.

A feature of the REVIEW is the section dealing with *New Biological Books*. In this department the book literature of different countries in the field of Biology is given prompt notice.


The QUARTERLY REVIEW OF BIOLOGY is issued in March, June, September and December.

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*Books for Review* may be sent to Dr. H. B. Glass, Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland.

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